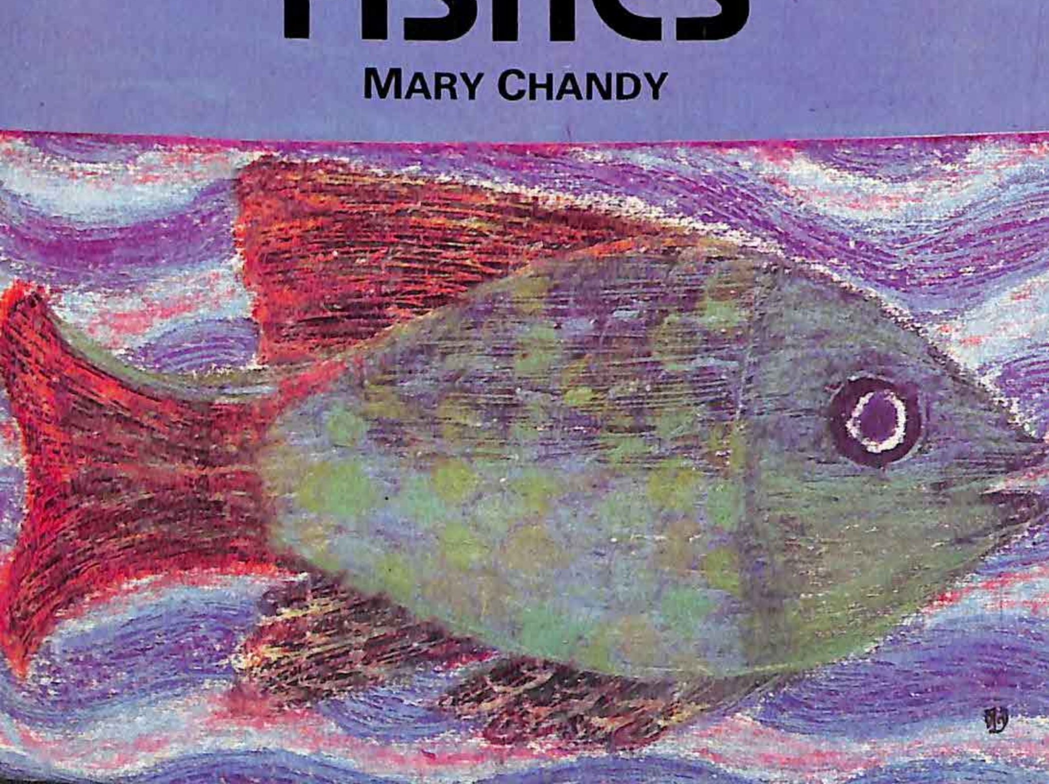
FISHES

MARY CHANDY



India—The Land and the People

FISHES

MARY CHANDY

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PREFACE

THIS BOOK is an attempt in the series, "India—the Land and People", which was started with the object of making available to the ordinary educated man knowledge about the various aspects of our country. Such books written for the laymen are scarce in India and I have tried to fill this gap to some extent.

The subject of fishes is biological and scientific. To make it popular, simple and yet factual has been my aim. As I have taught the subject to students in the University, it has been somewhat easy to achieve this objective. It is hoped that the general public will find that the book is not riddled with too much of scientific and technical jargon.

This book is divided into two parts. The first part deals with fish, its place in the animal kingdom, its remote origin and history and its peculiar structural features which are special adaptations for its life in water. A few of its fascinating habits like parental care and migration have also been presented.

The second part is a survey of our important fishes which inhabit the seas and rivers and their fisheries. As fishes provide food and several useful products to man, these topics are important from the point of view of economic development.

The book was first published in 1970. It has gone through three reprints. During the last two decades new discoveries and new facts on fishes have been added to our knowledge. Fisheries in India has developed by leaps and bounds. The need to revise the contents of the book is therefore compelling. I have tried to incorporate research findings on aspects like Venom, Sense organs, Shark menace and its counter measures.

The growth of fisheries in India as an industry is a spectacular feat, embracing the entire sub-continent. Under fresh water fisheries, pond-culture has reached methodical and scientific lines and commercial gains, with the introduction of mechanized boats, modern trawlers and gears, Marine Fisheries have expanded, so as to vie with foreign nations and as a valuable means to earn foreign exchange. A new chapter 'Fisheries Today' has been added to bring out the complex aspects of our sea-fisheries in their expansion, growth and industry.

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Further, I am deeply grateful to Dr. A.G.K. Menon, Emeritus Professor, Zoological Survey of India and his colleagues for their help in furnishing recent developments in fresh water fisheries and for certain corrections in fish classification. Also to Dr. P.S.B. James, Director Central Marine Fisheries Research Institute for providing with some of their valuable research publications. My sincere thanks are due to Dr. P.U. Verghese, Project Director, Marine Products Export Development Authority for their Reviews and latest statistics of the Indian fishery industry.

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PART I

CHAPTER I

INTRODUCTION AND CLASSIFICATION

FISHES MEAN different things to different people. To many fishes are perhaps best known as an article of food. To those who capture or trap them, they are a source of livelihood. To a selected few, they offer game or sport. What they are and how they came about need explanation.

Fishes are inhabitants of waters. In the Biblical story of Creation we read that God separated the land from the waters and the seas (thus formed) He inhabited with all kinds of creatures. Perhaps, it is no wonder that the word fish has been associated with quite a few unrelated animals. We hear of jellyfishes, crayfishes, cuttle-fishes and star-fishes which to a zoologist are not fishes at all, although they all co-exist in rivers, lakes and seas.

A true fish is a red-blooded, backboned animal which lives throughout its life in water. Its body is typically covered with scales. It breathes by means of gills. It propels itself by the sinuous movement of its body, aided by fins, which are the balancing organs.

CLASSIFICATION

Vertebrates or backboned animals fall into five distinct classes, namely, fishes, amphibians, reptiles, birds and mammals, in the order of their increasingly complex organisation. In other words, fishes are the lowest class of vertebrates belonging to the sub-kingdom Chordata, distinguished by *three* hallmarks as follows:

i) Presence of a series of disc-like bones, supporting the back column or its precursor, the notochord.

ii) Presence of a dorsal, tubular nerve chord, ending in a complex brain.

iii) The mouth passage is perforated by clefts—the gill-slits at some stage or other in the life of the individual. The clefts are open and functional only in aquatic vertebrates, such as fishes and amphibian larvae.

The simple classification of the sub-kingdom or phylum Chordata to which fishes belong is as follows:

Sub-phylum I: *Protochordata*

Class 1	Hemichorda
Class 2	Urochorda
Class 3	Cephalochorda

Sub-phylum II: *Vertebrata*

Class 1	Pisces including Cyclostomata
Class 2	Amphibia
Class 3	Reptilia
Class 4	Aves
Class 5	Mammalia

The early chordates are a very primitive group. They are animals which do not qualify in all particulars as vertebrates but do possess the three basic features mentioned above and are therefore labelled as chordates. They are interesting links between the vertebrates and the large assemblage of invertebrates (animals without backbones). They are, therefore, considered as borderline chordates or Protochordata consisting of three distinct classes: (1) the worm-like, burrowing animals, acorn-worms, *Balanoglossus* and their allies (Hemichorda); (2) the tunicates, or ascidians, popularly called sea-squirts (Urochorda); and (3) lancelets or *Amphioxus* (Cephalochorda).

The animals under the sub-phylum Vertebrata include from higher to lower types, the mammals (Class Mammalia), the birds (Class Aves), the reptiles (Class Reptilia), the amphibians—frogs and toads (Class Amphibia) and, lastly, the fishes (Class Pisces).

What did distinguish fishes from other vertebrates? Fishes, as already pointed out briefly, are purely aquatic cold-blooded creatures, breathing oxygen dissolved in water through

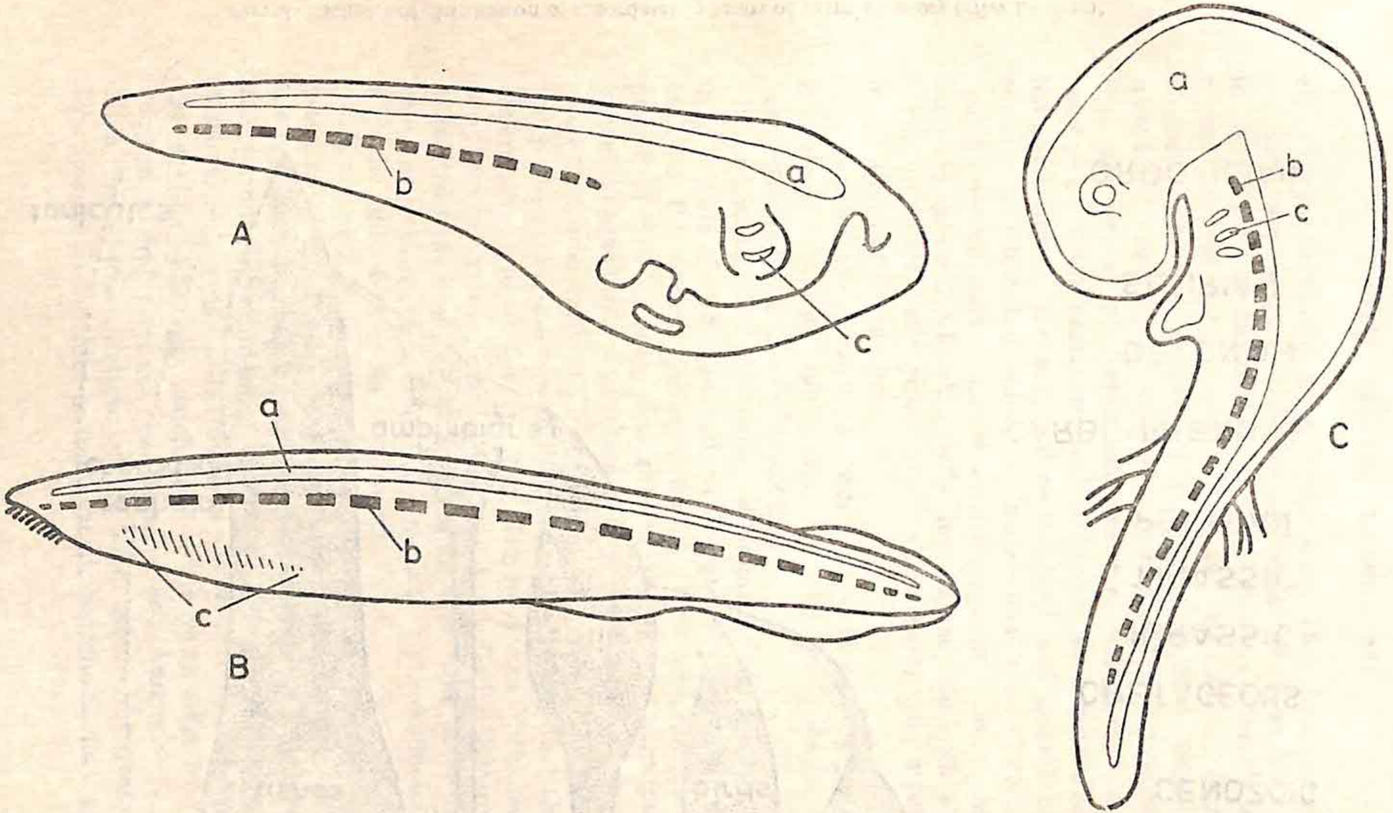

Fig. 1: Representatives of Chordates. A—tunicate larva; B—Amphioxus; C—chick embryo (*after* Lanham); a—dorsal nerve chord; b—notochord;; and c—gill-slits.

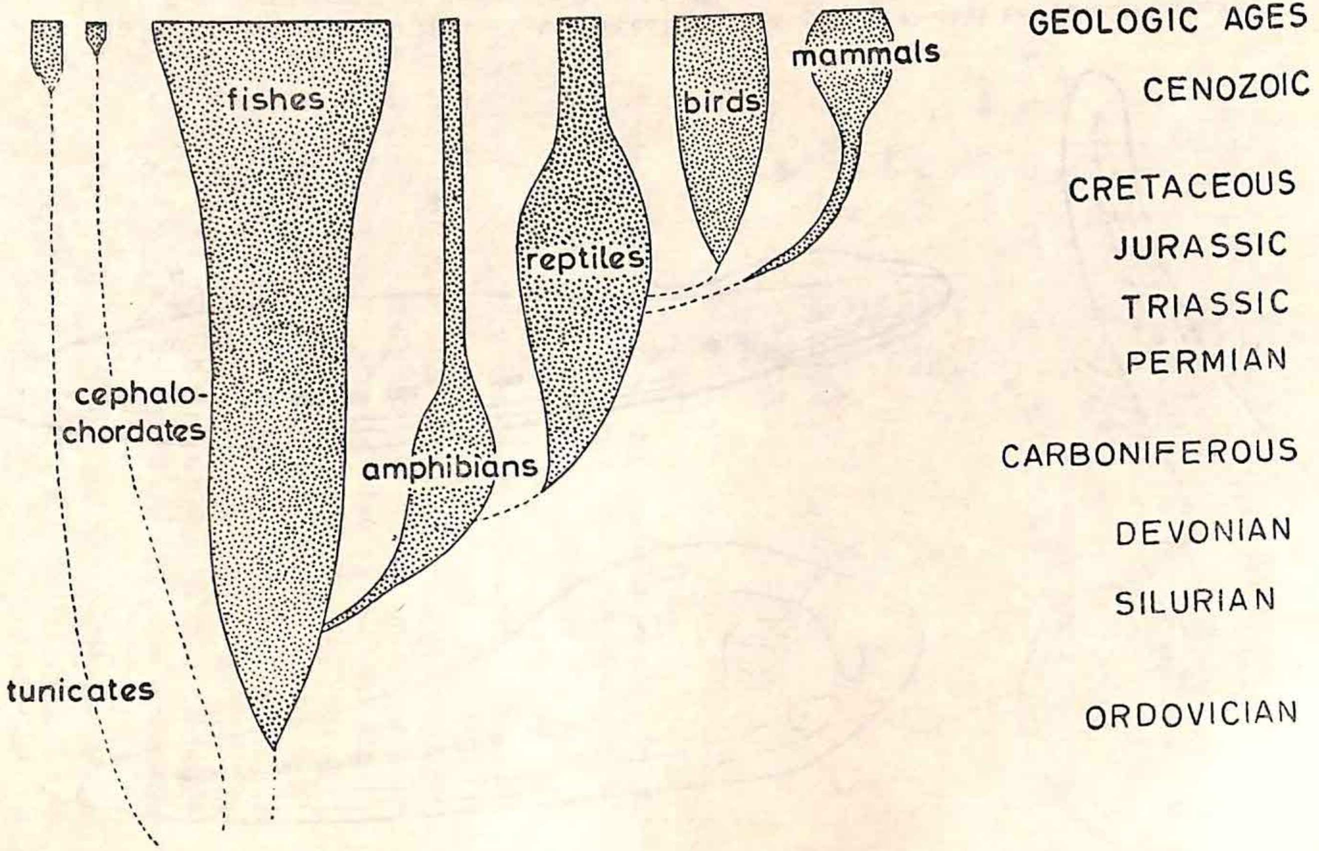

Fig. 2: Scheme of distribution of Chordates in terms of earth's history (*after* Lanham).

gills. They are devoid of a typical lung. They are provided with fins—appendages which help to balance and steer the body in its movements through water. The skin is covered with protective scales and is abundantly coated with mucus. Organs of smell, sight and hearing are found on the head. Olfactory sense is for smell only and is not concerned with breathing. Eyes are devoid of eyelids and the ears which are without external or middle parts are sunk within the skull bones. Peculiar sense organs are scattered on the head and lateral body surfaces to relate the animal to watery conditions of current, heat, pressure and possible electro-magnetic waves. Most fishes lay eggs which hatch directly into larvae, although a few bring forth alive their young ones, which develop for a period in the uterus of the mother.

Fishes of the present-day world may be broadly grouped into three important sub-classes, viz. (*i*) Cyclostomes, (*ii*) Cartilaginous fishes and (*iii*) Bony fishes.

The Cyclostomes, consisting of lampreys and hagfishes, are the survivors of a very old and peculiar group. Their origin dates back to the ancient geologic stratum, Devonian, the glorious period of fish dynasty. The title of the group Cyclostomata (round-mouthed) is derived from their unique feature of a cup-shaped mouth; further the mouth lacks true jaws, a character which this group shares with their extinct ancestors, the Ostracoderms (armoured fishes). The lampreys use their mouth to adhere to other fishes on whose blood they feed. Cyclostomes have 7-14 pairs of gills, which vary somewhat from other fishes, being pouches sunk into the body muscles and communicating with the gullet by a series of openings.

The lampreys are denizens of the sea and are distributed along the coast of North America, Japan and Europe. One of the best known is *Petromyzon*, the marine lamprey. It leaves the sea, ascends rivers and breeds in the sandy bottom of rivulets and streams. The parent fishes make a crude nest by pushing out the pebbles. The eggs hatch into larvae which differ from the adult in several respects. The larva called Ammocoete, is a blind, lancet-like creature with a hood around the mouth. It lives in streams for three or four years during which time it grows

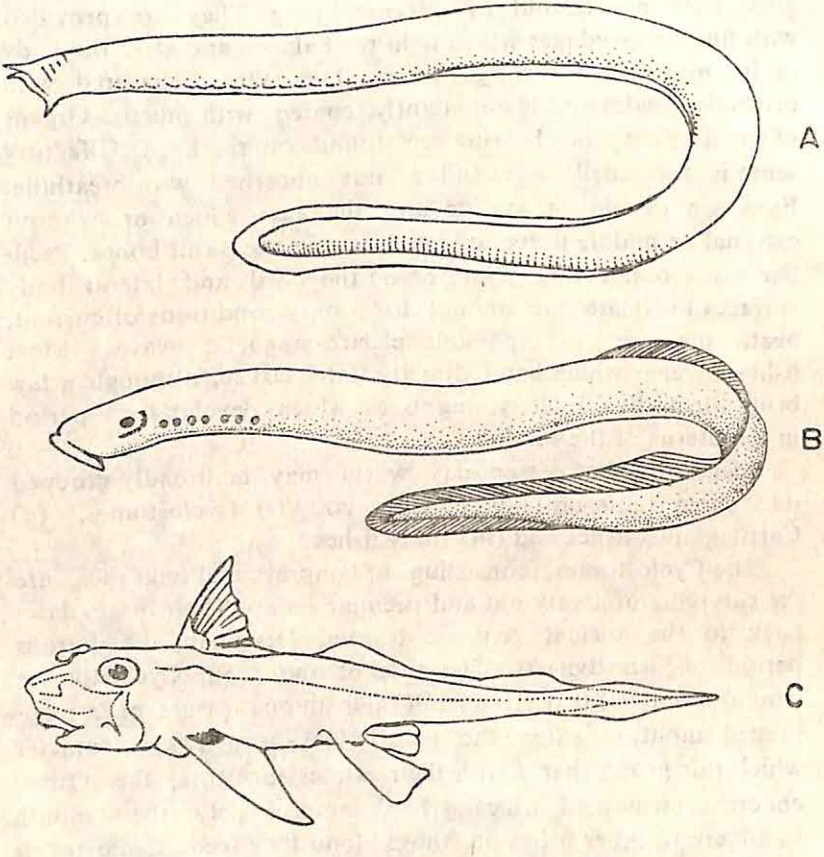

Fig. 3: A—Myxine (hagfish); B—Petromyzon (lamprey); and C—Chimaera (king of herring).

in size but does not attain sexual maturity. At the end of the larval period, it undergoes sudden and drastic changes in its form and structure and prepares to go to the sea, the home of its parents. The Ammocoete now becomes the young *Petromyzon* which adapts itself to marine life. with a suctorial mouth, feeding on the blood of other marine fishes. The gonads develop and the adult *Petromyzon* in the course of a few years repeats the story of the hazardous journey to fresh water. The life-cycle of a matine lamprey is a good example of anadromous migration, where the adult fishes migrate upstream for spawning.

Lamprey has a wide cup-like, suctorial mouth, the circular edge of which is beset with a fringe. Jaws are absent, but the inner surface of the cup is studded with yellow horny teeth The whole arrangement is well suited as a sucker to cling to other fishes and draw out their blood on which the lamprey feeds. It is very peculiar in its possession of a single nasal opening, through which water enters or leaves. Zoologists believe that it is a device to test water quality, while the mouth adheres to the substratum. On each side of the body, behind the eyes, are located seven circular gill-slits. The skin is naked, devoid of scales unlike their armoured ancestors. The inner skeleton consists of a peculiarly fashioned skull and a basket-like framework of gill arches. There are no paired fins. Median fins consist of two dorsals, a caudal and an anal. Because of their various peculiarities, it is often questioned whether Cyclostomes are true fishes.

Allied to the lampreys are the hagfishes, *Myxine* and other genera, usually found in deep seas. They never migrate to fresh water for breeding. Hagfishes lay eggs which are attached to seaweeds. Young ones resembling their parents hatch out. The mouth of the hagfish is round and jawless, but is surrounded by a set of filamentous barbels. Horny teeth border the lower margin of the mouth. Hagfishes feed on dead fishes into which they bore their way by eating the flesh and leaving out only the hard skeleton and outer skin.

The cartilaginous fishes (Chondrichthyes; Gr – Cartilage fish) comprising sharks and allied fishes are those in which the internal skeleton remains cartilaginous throughout their life, bone being absent. Sharks and rays belong to this group, which originated with other major classes of fishes in the Devonian period. Besides, the bizzare silver sharks or Chimaeras also fall under this class. They differ from true sharks in several important features so as to justify their separation into a distinct sub-class, Holocephali. In viviparous sharks, the eggs are fertilized in the oviduct and the embryos develop within the uterus. Several embryos may develop at the same time.

Each embryo is held to the uterine wall by means of its yolk sac—a sac-like growth extending from the embryonic gut and containing food for the young. The sac gets connected to the inner wall of the uterus to form a rudimentary placenta, an organ which is best developed in mammals. When the development is complete, the young sharks, resembling the parent in all details are extruded through the cloaca. The class is predominantly marine and some of them live in estuaries and mouths of mighty rivers like the Amazon, the Ganges and the Tigris, ascending upto the limit of tidal waters.

Chondrichthyan fishes have a number of peculiar features in their anatomy, besides what had been mentioned above. Their body is covered by microscopic, teeth-like scales, the placoid denticles. The gill-slits open directly outside; in other words, they are not covered with a gill cover. Most of them are carnivorous and ferocious creatures armed with large cutting teeth. Viviparity is common, although a few lay eggs.

One of the well-known sharks of the Indian seas is *Scoliodon*, familiar to all students of biology. Its small size and ready availability make it a convenient type for laboratory work. Like most sharks, it has a fusiform, laterally compressed body with a prominent head. Gill-slits are five in number. There are some primitive sharks with 6 or 7 gill-slits; the eyes are large and dorso-lateral. In some sharks and dogfishes, behind the eye is a slit, the spiracular opening, which communicates with the pharyngeal cavity. The mouth is on the ventral side of the head, away from the anterior tip of the snout. In front of the mouth at each of its angles is the nasal organ. There are well-developed median and paired fins. The caudal is prominently heterocercal (lobes unequal). In the male fish, associated with pelvic fins, is a pair of grooved appendages, the copulatory organs. A large cloacal opening (combined opening of the alimentary canal, the openings of the ureters from the kidneys and the genital duct) is seen between the bases of the pelvic fins.

Sharks are the largest fishes living today and are abundant in the tropical and sub-tropical zones of the world. Indian seas are rich in sharks and we shall consider their names and descriptions in a later chapter.

Rays differ from sharks in the shape and organization of body, which can be illustrated from an example like sting ray, *Dasyatis*. Its body is round or rhomboidal. The pectoral fins have become so large as to extend forward and backward and also to fuse with the head to form a disc, which is distinct and separate from the whip-like tail. The dorsal median fins are carried to the tail and may become small or may even disappear. The gill-slits are ventral in position. By habit, rays are bottom-living and feed on small organisms like prawns, snails, etc. The mouth is small and ventral. It is bound by jaws which bear microscopic teeth arranged like tiles on a pavement. The majority of rays, like sharks, are viviparous, but some of them lay eggs in specially designed horny capsules. The sting ray is famous for its stinging apparatus, which is nothing but a serrated spine, 1-2 inches long, with poisonous glands running along its two marginal grooves. When trod upon, the fish inflicts a nasty painful wound, which at times may prove fatal.

Chimaeras, noted for their grotesque appearance, are popularly known as king of herrings or spookfish or silver shark. They are found on the coasts of Europe, Japan, Australia and the eastern coast of North America, the Cape of Good Hope and the Indian Ocean. Its body is shark-like. but the large compressed head and the small mouth are strikingly different from the depressed, shovel-headed and wide-mouthed shark. The mouth of a Chimaera is bounded by lip-like folds. There is only a single external branchial opening. This is because a fold of skin, the operculum, extends backwards from the region of the hyoid arch and covers the true gill-slits, a condition very much like that of the bony fishes. Spiracle is absent. The openings of the rectum and the urinogenital ducts are separate, there being no cloaca.

There are two dorsal fins and a small ventral. The tail is produced into a long whip-like filament. The pectoral and pelvic fins are large, the latter in the male carries with it the clasper. In addition, there is a frontal clasper on the head, the function of which is not understood. Teeth are peculiar. They are in the form of strong plates with an irregular surface and a sharp cutting edge.

Breeding and development have been studied in the Pacific Chimaeras by a noted American zoologist, Bashford Dean. Chimaeras spawn all the year round. Eggs are fertilized inside the uterus and are enclosed in capsules, which are large brown and heavy when extruded. Each capsule is fixed to the inner wall of the uterus and is shaped like the tadpole of a frog and has a snout, trunk and tail with sheath. The capsules are often seen protruding from the mouth of the uteri. When finally laid, they get attached to rocks or seaweed. Development of the embryo takes place within the egg capsule where the young Chimaera spends 9-12 months.

The bony fishes (Osteichthyes), as the name suggests, are those in which bone is the chief tissue of skeleton as compared to cartilage of Chondrichthyes and Cyclostomes. In several ways, bony fishes are a higher group and embrace three distinct sub-divisions, the lobefins (Crossopterygia), the lung-fishes (Dipnoi) and the modern teleosts (Teleostei).

The Crossopterygians were till recently thought to be an extinct group. The discovery of a strange fish, a coelacanth (*Latimeria chalumnae*) in 1938 in the Mozambique Bay, off east Africa, has opened up a new approach to the study of this group. As the sole survivor of a very old and interesting group, its anatomy has been thoroughly investigated by leading scientists. Attempts have also been made to study some of its habitats in natural conditions.

One of the diagnostic features of the Crossopterygians is the presence of a prominent muscular basal lobe in the pectoral and pelvic fins, whence the name lobefins. Besides, their tail-fin is also peculiar, being tri-lobed. These fishes lived in swamps of the Devonian period and are believed to have developed lung-like structures for breathing. The most primitive of lobefins, rhipidistians possess characteristic teeth, where the enamel is highly crinkled into the dentine, forming an intricate pattern. Peculiarly enough, this feature is shared by the first amphibians, Labyrinthodonts. Because of this close similarity, the lobefins have been considered as the probable ancestors of Amphibia, This view is further supported by the nature and structure of the paired fins which are prophetic of the limbs of land vertebrates and also by the presence of lungs in the Crossopterygian fishes.

Coelacanths to which the *Latimeria* belongs is another subdivision of the Crossopterygia. They were fairly abundant in the Devonian period and were inhabitants of fresh waters. One group subsequently left the rivers and streams and went down to the sea. The lungs were superfluous in the oxygen-enriched sea-water and consequently these organs became smaller and calcified. On account of the close relationship between coelacanths and rhipidistians, the discovery of *Latimeria* was a sensational one, as it was hoped that it might give a clue to the origin of land vertebrates and perhaps even man. But to the specialist, it is just a strange fish, which is not even in the direct phylogeny of the first terrestrial vertebrate. However, its anatomy has been studied in minute detail and it has been shown that its heart and brain bear similarities to the extinct land vertebrates of old. Since 1939, several attempts have been made by biologists to capture more *Latimeria* fishes and observe their habits. The fish is about 5 feet long and weighs about 127 pounds.

Related to the lobefins is another interesting group called lung-fishes or Dipnoi. Fishes generally breathe dissolved oxygen in water that bathes their gills; but a few like the lung-fishes have developed lung-like structures, which enable them to take in oxygen from the atmospheric air. Dipnoan fishes are now found in certain parts of Australia, Africa and South America.

The Australian lung-fish, *Epiceratodus*, is found today in the rivers of Queensland. It lives in shallow pools or water-holes and comes to the surface for breathing. It is a valuable food fish and being sluggish, it is easily captured. Fearing its extermination, the Australian Government has enacted a law prohibiting its capture or destruction.

The African lung-fish, *Protopterus*, is found in the tropical parts of that continent, where it has a fairly wide distribution. It lives in swamps which dry up partially or entirely during the

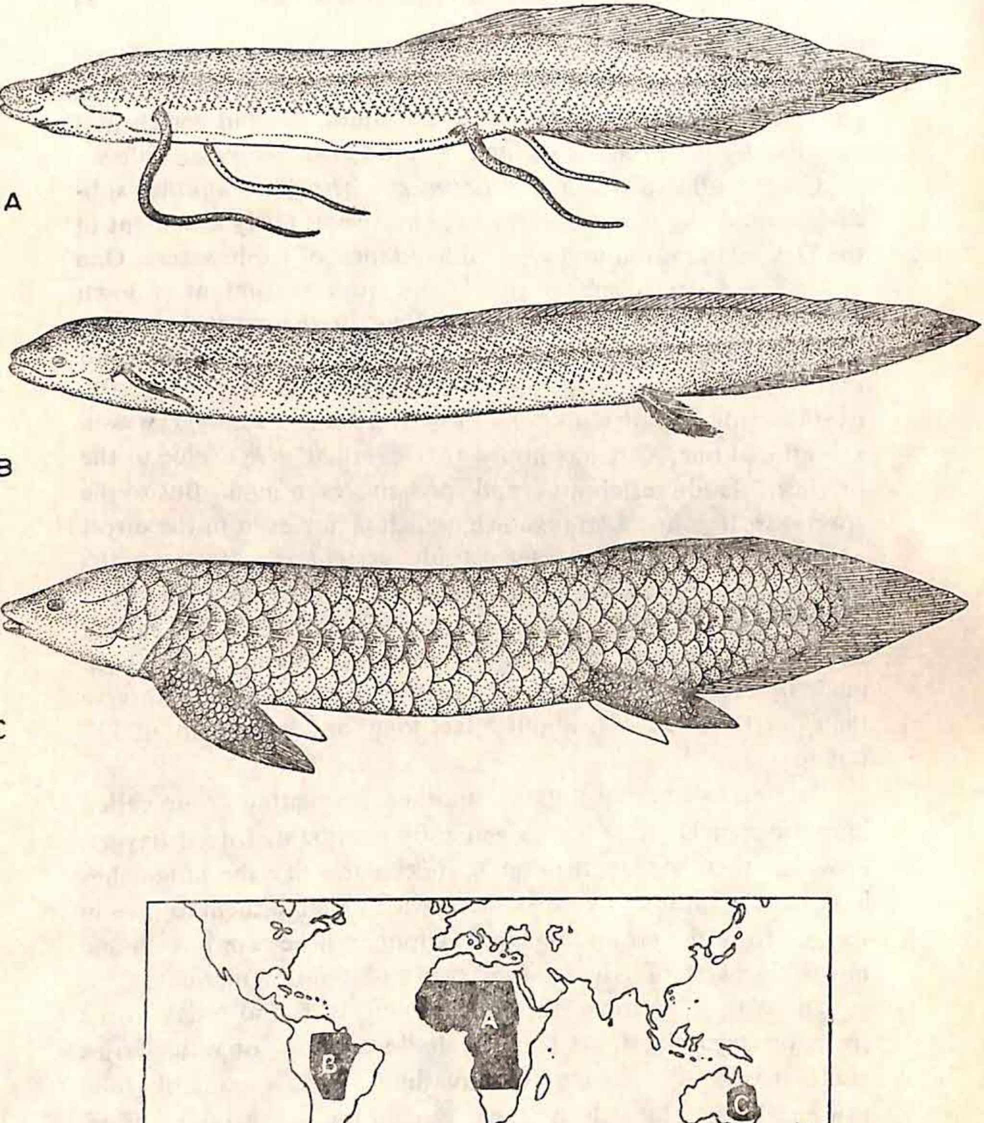

Fig. 4: Lung-fishes and their geographical distribution (*after* Norman).
A—*Protopterus*; B—*Lepidosiren*; and C—*Epiceratodus*.

severe hot summer. The fish overcomes the drought by burrowing into the mud, where it makes a temporary nest and 'sleeps' until the outbreak of the rainy season. During this period of aestivation, the fish subsists on stored fat and breathes through air passages left on top of the mudburrows.

The South American lung-fish, *Lepidosiren*, is an inhabitant of the tributaries of the Amazon. It closely resembles the African member in appearance and habits.

Lung-fishes were abundant in the Devonian and subsequent periods and had wide distribution as indicated by fossil deposits in several parts of the world, like North America, the Indian peninsula and Europe.

The bony fishes (Osteichthyes) also had their origin in the Devonian. But the early ancestors differed somewhat from our modern forms. These ancient types of bony fishes have been lumped together as 'Ganoid fishes'. Their bodies were covered with an armour of shiny, thick, rhombic ganoid scales. They had large jaws with piercing teeth and their skeleton was partly cartilaginous.

The present-day survivors are the sturgeons (*Acipenser*) of Russia and the paddle-fish (*Polyodon*) of the lower Mississippi river and garpike (*Lepidosteus*) of North America. Sturgeons are important edible and commercial fishes of Russia. The widely renowned delicacy, known as 'Caviarre', is the fish eggs, cured and processed. Their air-bladder yields very fine isinglass used in the clarification of wine. Garpike is peculiar in the possession of a sword-like beak, armed with strong teeth. The scales are typical ganoid scales, rhombic in shape and thick in nature.

The bichir (*Polypterus*) of tropical Africa also has an armour of shining diamond-shaped plates. Its head is covered with a bony shield and its dorsal fins are divided into many finlets. *Calamoichthyes*, which lives in West Africa, is the only other genus of the Polypterini group. It has a long eel-like body. In both these fishes, the paired fins are paddle-like, with a distinct stout, muscular base and radiating fin-rays reminiscent of the fossil lobefins, with which they were once grouped. But recent authorities differ in their opinion on account of several important differences in structure between the two groups and prefer to consider Polypterini fishes as early Ganoids.

The modern bony fishes are grouped under Teleostei which means that their endoskeleton is totally bony without any trace of cartilage. Teleosteans had their origin roughly about 60-120 million years ago in the Cretaceous period. Thin, round and overlapping scales, fan-shaped fins supported by segmented fin-rays; an equally lobed tail-fin and a hydrostatic float are the diagnostic characters of the group.

Cyclostomes, sharks and lung-fishes, though extremely archaic and varied, are interesting groups and make up a small fraction of the fish fauna of the present day but about 90 per cent of fishes may be said to belong to Teleostei. Teleosts are a very diverse group, inhabiting rivers, lakes, estuaries and seas.

The classification of this rich and widely distributed group is so controversial a matter that no two authorities seem to agree. However, most zoologists divide them into about 40 or more major groups or orders. Here it would suffice if we consider three or four of the more important orders which embrace most of the familiar fishes. These are:

Order Isospondyli (Clupeiformes)
Order Ostariophysi (Cypriniformes)
Order Acanthopterygii (Perciformes, etc.)
Order Heterosomata (Pleuronectiformes).

The order *Isospondyli* includes clupeid fishes like sardines, herring, salmon, the famous *Hilsa* and *Chanos* (milk-fish) of Indian waters. Clupeid fishes are found all over the world and live in big shoals or schools. They are highly esteemed as food and are therefore commercially important in Europe, America and Japan. In the nature of their vertebral column, fins and airfloat, they are relatively so primitive that taxonomists look upon them as ancestral stock of the modern teleosts. Isospondylous fishes have diverged into many sub-groups which show a wide range of body form, snout, mouth and its associated jaws and teeth, indicative of differing food habits.

The members of the order *Ostariophysi* are mostly fresh water fishes. A unique feature of these fishes is the presence of a

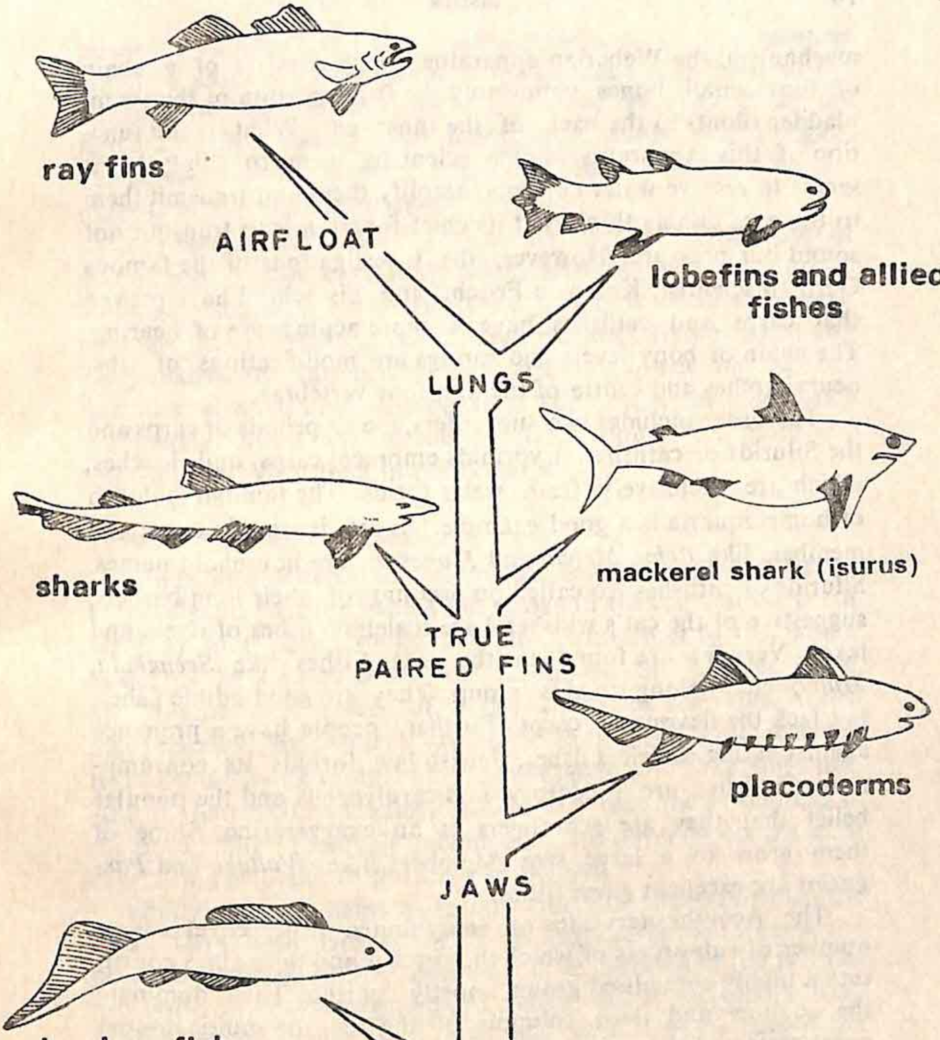

Fig. 5: A schematic representation of the evolution of fishes, showing major adaptive steps (*after* Lanham).

mechanism, the Weberian apparatus, which consists of a chain of four small bones connecting the front portion of the swim-bladder (float) to the back of the inner ear. What is the function of this apparatus? Some scientists seem to think that it serves to receive water currents, amplify them and transmit them to the ear. Others think that its chief function is to transmit not sound but pressure. However, the investigations of the famous German scientist, Karl von Frisch, and his school have proved that carps and catfishes have a more acute sense of hearing. The chain of bony levers and springs are modifications of ribs, neural arches and centra of the first four vertebrae.

The order includes two sub-orders, the Cyprinids or carps and the Silurids or catfishes. Cyprinids embrace carps and loaches, which are exclusively fresh water forms. The familiar goldfish of home aquaria is a good example. India is rich in carps and members like *Rohu*, *Mrigal* and *Mahaseer* are household names. Silurids or catfishes (so called on account of their long barbels, suggestive of the cat's whiskers) are scaleless fishes of rivers and lakes. Very few are found in the seas. Fishes like *Seenghala*, *Mully*, etc. belong to this group. They are good edible fishes, but lack the flavour of carps. Further, people have a prejudice against eating scaleless fishes. Jewish law forbids its consumption. Catfishes are predatory and carnivorous and the popular belief that they are scavengers is an exaggeration. Some of them grow to a large size. Members like *Wallago* and *Pangasius* are excellent game fishes.

The Acanthopterygians or spiny-finned fishes cover a large number of sub-orders of which the perches and their allies constitute a highly specialised group, mostly marine. They dominate the shallow and deep columns of the sea, the multicoloured coral reefs and the open oceanic waters.

Perches have several distinguishing features. Prominent needle-like spines in the fins are characteristic. The air-bladder is a closed sac (physoclistic) with extra contrivances like gas-glands associated with an intricate and wonderful network of blood capillaries, 'rete mirabile'. The scales are thin, overlapping and cycloid. In a few groups the free edge of the scale bears rows of teeth, giving a comb-like appearance. Such a scale is termed ctenoid. The pelvic fins are located in the thoracic region, a position conducive to greater balance in fishes with a closed swim-bladder. Most of the commercial fishes of the sea like Serranids, Lutianid fishes, *Betki* (*Lates calcarifer* of Bengal), mackerels, tunas, mullets, carangids, etc. come under the diversified Acanthopterygians.

The Heterosomate fishes are the highly specialised group of 600 or odd species, commonly called flat-fishes or tongue-fishes. They are sluggish, sedentary types that have become adapted to living at the bottom. Their head becomes asymmetrical and body extremely flattened. There are no spines on the fins and the airfloat also disappears. The order includes such commercial fishes as flounders, soles, halibut, etc., more well known in the West than in our country.

FOSSIL FISHES (fishes of old)

We cannot understand present-day animals, unless we have a knowledge of past life, which lies buried in the crust of the earth. Geology and palaentology help us to interpret fossils, which, as defined by a noted British palaentologist, Sir Charles Lyall, are "any body or traces of body, animal or vegetable, buried and preserved by natural causes." Every fossil is either ancestral to some living thing or is representative of an extinct line. And in the words of Huxley, "fossils are only the skimmings of the pot of life; although incomplete, it is nevertheless the most convincing evidence of the story of the past."

Study of fossils helps us to find out the order in which the rocks have been laid down. It is also desirable to know the probable time of origin, duration of existence and the rates of evolution of particular groups of living things, Scientists have several reliable tools to probe into these. One of these is the principle of radioactivity. Elements like uranium and thorium are known to disintegrate at rates which are unaffected by any known condition. In the case of uranium, it gives off rays in a slowly descending series, extending over millions of years and finally becomes residual lead. The mass of lead, when measured, becomes a factor from which the age of particular strata or rocks can be calculated.

The oldest fish fossils have been unearthed from the rocks of the Ordovician period about 400 million or more years old. These archaic stocks are the Ostracoderms or armoured prehistoric fishes. As the name suggests, they were clad in heavy, bony armour. Besides, jaws were absent. The gills were placed in a series of pouches, outgrowths of the gullet and opening externally by a corresponding number of circular slits. These same characters are retained by lampreys and hagfishes described earlier under the group Cyclostomes. The extinct Ostracoderms and the present-day Cyclostomes are therefore closely linked. Zoologists have grouped them together under the common class Agnatha, although no fossil link has been found so far.

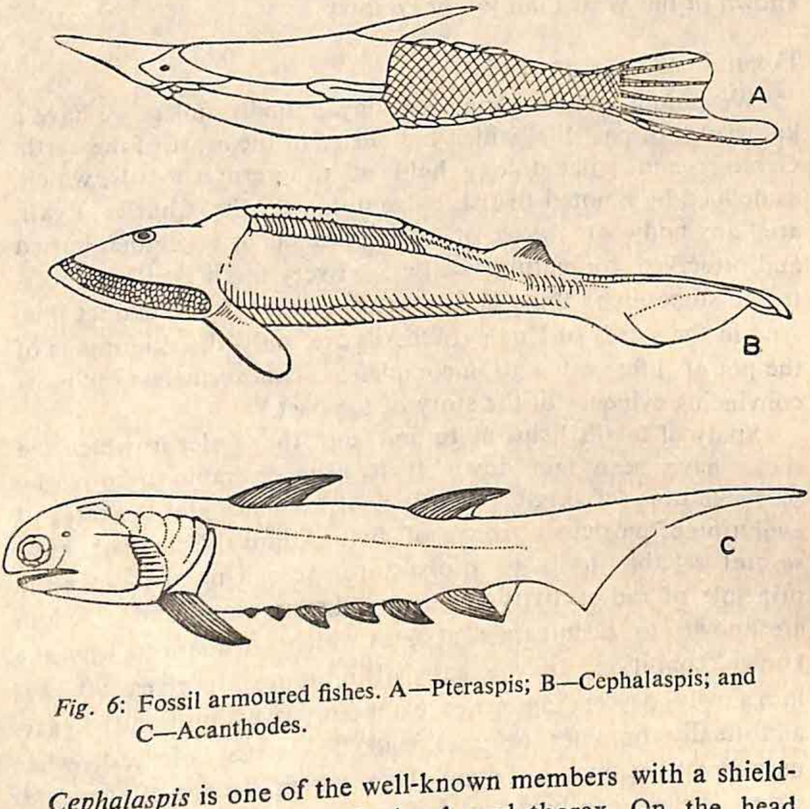

Fig. 6: Fossil armoured fishes. A—Pteraspis; B—Cephalaspis; and C—Acanthodes.

Cephalaspis is one of the well-known members with a shield-like armour, which covers the head and thorax. On the head are found patches, two or more, which seem to have lodged some organs, believed at first to be of the nature of electric organs. A recent view is that they may be some specialised receptor organs, which had connections to the ear and therefore may have been of the lateral line or neuromast organs for detection of water currents. Most of the cephalaspids and their close relatives were all sluggish, slow-moving, bottom-dwellers of the Silurian and Devonian periods.

Pteraspis is often found along with the above genus. Its body was fusiform; the head and trunk were encased in a series of plates and although it had only median fins and no paired fins, it is supposed to have been a more active and fast-moving fish.

Different from the two armoured fishes mentioned above were the Anaspid fishes, of which *Birkenia* is a typical one. The body is elliptical, with a prominent two-lobed tail-fin, Paired fins are well developed. All these features point towards the attainment of a higher level of organisation and a state of greater mastery of the aquatic medium.

These Ostracoderm fishes are the first backboned animals. Their muscles helped them to propel the body but in general they lacked the fins which control balance and steering. They had a round, jawless mouth, which provided a primitive feeding apparatus for the intake of microscopic organisms.

Placoderms (plate-skinned), also armoured, constitute the second major group of fossil fishes. They were abundant in the Devonian and became extinct in the Carboniferous. In the evolution of fishes, Placoderms are considered a very important group, for it is in this group that true biting jaws were first evolved, an event which revolutionised the success of the vertebrates.

In the Agnathan fishes the successive gill-slits were supported by cartilaginous or bony bars, which were hinged in the middle like the letter 'V', with the opening facing forward. The gill-bar or arch which bordered the mouth on each side became associated more with feeding than with breathing, Thus, the arch became more pronounced and stronger than the succeeding gill-bars. The dorsal half became the upper jaw, while the ventral half was modified as the lower jaw. Side by side, the mouth became enlarged and the muscles developed, leading to an efficient biting mechanism that could attack larger organisms. Teeth which are believed to be modifications of the skin covering the jaws, further helped in catching and tearing the prey. Thus, the Placoderms, inventors of jaws, ousted the clumsy, sluggish, jawless fishes.

Placoderms are presumably the ancestors of sharks and bony fishes. In the Placoderms only the first pair of gill arches took part in the evolution of the jaws. The sharks went a step further. Here the second gill arch also passed through interesting changes. It moved forward obliterating the gill-slit in front partially, leaving a small passage, the spiracle. Its upper half was converted into a buttress or suspensorium to support the jaws from the skull. This was no doubt an improvement, as it provided greater freedom of movement for the jaws.

A noted group amongst the Placoderms is the Acanthodians (so-called 'spiny sharks') which ranged from the upper Silurian through the Permian period. Their small, streamlined body was equipped with a paired pectoral and pelvic fins. Some had even 3 or 4, sometimes 5, additional pairs of fins lined up between the pectoral and pelvic fins. Each of these fins, though lacking in supporting rays, was strengthened by a stiff spine in front, which improved the utility of these appendages as balancing and steering aids. In addition to the paired fins, the Acanthodians had a median dorsal fin (1 or 2) and a ventral or anal fin both supported by spines. The caudal fin consisted of two unequal lobes—heterocercal type—as in the sharks. The skin was covered with small denticles, somewhat similar to those of sharks. Thus with the arrival of the Acanthodians, with their fusiform body, flexible external skin covering, and a full set of fins, we can say that fishes had attained their modern look. The Acanthodians may, therefore, be looked upon as the type from which the ancestors of the later jawed fishes arose.

Fossil Sharks

The Placoderms which were considered in the previous section lived in the Devonian period side by side with the Ostracoderms. The former with their jaws, well-developed fins and reduced exoskeletal armour were a superior race. While the Ostracoderms disappeared by the end of the Devonian, the Placoderms marched forward for another 100 million years before they too became extinct during the Permian.

Sharks also were among the early jawed fishes of the Devonian period. Their first emergence is obscure. The mysterious fossil records of small, hard, tridentate teeth 'conodonts' in the Silurian and Devonian rocks have been thought by some palaentologists to belong to some early sharks.

The oldest known shark, *Cladoselache* (finfold shark) lived in the Upper Devonian, about 300 million years ago. The fish, about three feet long, had a beautiful streamlined body with a pair of well-defined pectoral fins, suggestive of the wings of a modern aircraft. The paired fins have a broad base, supported by simple rays. The tail-fin is modified heterocercal, with a distinct lateral keel (or fold of skin) on each side, which is a device, probably, for speedy movement.

The ancient Cladoselachians became extinct during the Permian. They were replaced by more progressive sharks, one of which is the well-known *Hybodus*. This model of sharks actually arose in the Devonian, continued through the Carboniferous and the Permian of the Palaeozoic and the entire Mesozoic era, at the end of which it disappeared. Hybodus sharks were about 7.5 ft. long, with a well-proportioned body and large fins. In the male the pelvic fins were associated with 'claspers', an intromittant organ. Fertilization was internal, a feature which is very common in all subsequent sharks. The teeth are short and blunt and it is believed that these sharks were omnivorous in habits. Modern forms like the Port Jackson shark (*Heterodontus*) are very similar to these extinct types. Sharks were abundant and varied in the Coenozoic era. Three distinct lines of evolution are observable—the Scylloids consisting of the large-sized sharks, tiger sharks, whales, blue sharks, etc.. the Squaloids, including the small dogfishes, *Squalus*, etc., and the rays, the dorso-ventrally flattened and bottom-living forms which moved by the undulations of their enlarged pectoral fins.

The rays are an offshoot of the Selachians. The event most probably took place in the Jurassic. Rays now embrace 9–10

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distinct families, differing from one another in several structural features. The body is depressed and consists of a disc and tail. The five gill-slits are ventral and the eyes are dorsal. Behind each eye is a slit, the spiracle, vestige of the once functional gill-slit between the first and the second pharyngeal arches. Spiracle is put to a new use in the rays. Being bottom-living, they do not draw water for breathing through the mouth, lest mud and sand clog the passage. Instead, the respiratory current is drawn through these spiracular openings. The pectoral fins are enormously expanded and are the sole organs of locomotion in this group. Teeth are small, sometimes microscopic and are set in bands or pavements. Rays feed on crustaceans, molluscs and small bony fishes.

The *Chimaeroids* or silver sharks represented today by *Chimaera*, *Callorhynchus* and *Harriotta*, all deep-sea fishes, are a distinct offshoot of the earliest cartilaginous fishes during the Triassic. They flourished in the Cretaceous, 60–120 million years ago. The best fossil example is *Helodus* (Lower Carboniferous), which showed a number of shark-like characters. The head is large and peculiarly shaped, while the body tapers into a filament. The skin is smooth, the placoid denticles having disappeared. The upper jaw is fused with the skull. The jaws bear short, blunt teeth, which are only a few in number. These teeth have so characteristic patterns that scientists can easily name the fishes which possess them. In many instances, they are the only relics left behind by the fishes that belonged to the Chimaera.

THE LUNG-FISHES (Dipnoans)

The earliest record of lung-fishes is *Dipterus* in the Devonian. It had two dorsal fins and an unequal tail-fin. The head was covered with numerous small, enamel-coated bones. The scales of the body were thick and rhomboid, made of cosmine, (a special chemical substance) and therefore named as 'cosmoid'. It resembled the earliest Crossopterygian, *Osteolepis*. The lung-fishes progressed through the ages almost with unbroken continuity, as seen in the fossil remains of fishes such as *Phaneropleuron*, *Scaumenacea* and *Ceratodus*. *Ceratodus* differs in appearance and structure from its earliest ancestral form, *Dipterus*. The two dorsal median fins have fused into a continuous fringe. The scales have become thinner and the body shape has become uniformly cylindrical. This genus though world-wide became extinct at the end of the Triassic and was replaced by a closely resembling successor, *Neoceratodus* of Australia.

Of the lobefins (*Crossopterygians*), *Osteolepis* is the most typical and most widely known. The pectoral fin as well as the pelvic fin had a distinct lobe, as described in *Latimeria*. Osteolepid scales were cosmoid and the teeth labyrinthodont. The skeleton of the paired fins and skull resembled the class Labyrinthodontia, which characters seem to establish the view that the amphibian stock arose from the Osteolepids. Another well-established group of lobefins is the coelacanths of which *Latimeria* is the sole survivor.

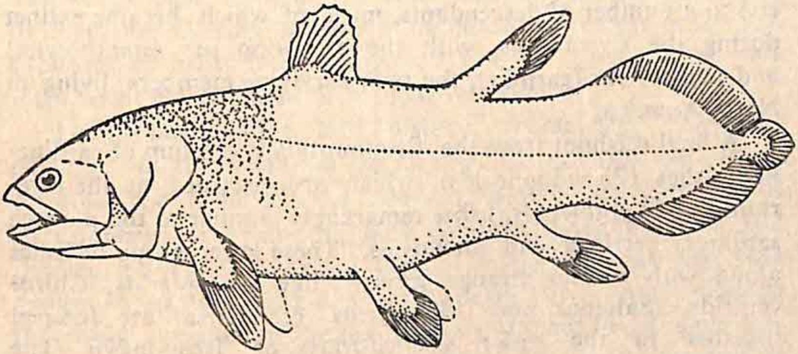


Fig 7: Latimeria (coelacanth fish).

The earliest fossil members of the bony fish group were the Palaeoniscids, a family of armoured fishes, which first appeared in the lower Devonian, radiated out into the Carboniferous and Permian periods and finally came to extinction towards the end of the Jurassic *Palaeoniscus*, the central example of this group, is a somewhat elongate fish, with a fusiform body tapering into a conspicuous heterocercal tail and a single dorsal fin. There was a complete covering of exoskeleton of rhomboidal, thick ganoid scales on the trunk and tail, while the head was covered with a series of plates. The mouth was large and the jaws were armed with sharp, pointed teeth. The shape of the body, the nature of fins and dentition suggest that these early ancestors of the bony fishes were fast swimmers and predacious by habit.

In the late Permian, while these primitive bony fishes were declining, a wave of new types was advancing. It is now believed that the vast majority of our modern fishes are the descendants of this radiation. A typical example is *Lepidotus* of the family Semionotidae which lived in the Triassic and Jurassic periods. Semionotids were stout-bodied fishes, the caudal portion being short. The tail-fin was equal-lobed (homocercal). Most probably they were slow swimmers. Their small mouth and round molar-like teeth indicate that they fed on shell and cray fishes. During their prime days, the Semionotids gave rise to a number of descendants, most of which became extinct during the Cretaceous, with the exception of *Amia* (bowfin) and *Lepidosteus* (garpike), the two surviving members living in North America.

A final offshoot from the Semionotids is a group of sardine-like fishes (Pholidophorids), which are regarded as the fore-runners of Leptolepids, fishes remarkably similar to the modern sardines, herrings and anchovies. These latter group of fishes along with certain strange groups like Notopterids, Chirocentrids, Salmons and Mormyrids of Africa are lumped together in the order Clupeiformes or Isospondyli. The Cretaceous was a critical period for this order as it underwent rapid evolution, which led to the rise of a large number of newer groups, which are now at the base of the teleostean tree. Perches and their allies, which are considered as the culmination of teleostean radiation, did not make their appearance until towards the end of the Cretaceous. It was in the succeeding geologic period, Eocene, that the rise of specialised orders such as the mackerels, tunas, scorpion-fishes, sucker-fishes, file-fishes, anglers, coffer-fishes, etc. took place.

THE ORIGIN OF FISHES

That life originated in the sea is an accepted fact. How the mysterious and wonderful substance called, 'protoplasm', was fashioned nobody can tell. In the warm and dimly-lit waters of the sea, the unknown conditions of temperature, pressure and saltiness must have provided the crucial conditions for the creation of life from non-life. The first living thing may have been simple micro-organisms like bacteria and amoeba. As the years rolled by—maybe millions and millions of them—living forms grew more complex, giving rise first to simple multicellular and later to more highly organised animals such as jelly-fishes, worms, prawns and crabs, snails and slugs and star-fishes—all without a backbone. Then emerged a new group—the early and primitive backboned animals like the sea-squirts and lancelets. The sea was the stage for these dramatic events. Fishes, tapered of body and streamlined by the pressure of running water, evolved in the Silurian rivers or possibly the Ordovician. The rocks bear evidence to this. Also the kidney—an organ or device for filtering for the elimination of excess water and expulsion of poisonous nitrogenous wastes—gives a clue to a fresh water environment of the first vertebrates.

Fishes have had a long history. Their first emergence occurred about 430 million years ago. During this vast stretch of time, the have become adapted to all conceivable aquatic environments. They are the most common forms in rivers and rivulets, lakes and estuaries. They roam the open seas and have descended into the dark depths of oceans. They have climbed the rapid torrents of the mountains and crept into the crevices of cave waters. The evolutionary history of fishes is a fascinating story, cramped with adventures and triumphs, but also not without its setbacks and defeats. It is estimated that there are about 25,000 species of fishes living today. They are second to insects in the largeness of population and they outnumber all other vertebrates, mammals, birds, reptiles and amphibians put together.

When, where and how did fishes arise? Biology attempts to answer such questions in a scientific manner by gathering information and evidence from different sources, such as geology (history of the earth), palaeontology (history of fossils), anatomy and embryology of animals.

Let us first turn to the earth of the Cambrian period about 400-500 millions of years ago. Here we meet with a large number of animals—jelly-fishes, corals, crustaceans, trilobites—all without backbones. There is no trace of fishes, not even any of the primitive chordates. We may infer that fishes had most probably not come into existence so far. The clue to the first fishes is found in the next geologic period, the Ordovician (360-400 million years ago). Fragments of bone which resemble the armour of well recognized fishes like *Pteraspis* and *Cephalaspis* are found, leading us to believe that a group of early vertebrates with a skeleton and probably other well-organised systems had evolved during this period. Beyond this, fossil records do not tell us anything more. Who the ancestors were and how exactly they evolved are problematic questions. To try to answer them, we have to turn to other branches of science.

Fishes, as we have seen, belong to the sub-kingdom or phylum, Chordata, which includes all animals with a dorsal stiff support or chord, from *Amphioxus* right up to mammals. In the five higher classes, fishes, amphibians, reptiles, birds and mammals, the dorsal support, the notochord, gets modified into a series of discs, over which other skeletal pieces like neural arches join to give rise to vertebrae. These classes, therefore, constitute the vertebrates. It is among the lower chordates—*Amphioxus* (lancelet). Ascidians (Sea-squirt) and the Balanoglossids (acorn worms) that we have to search for possible ancestors. It is most obvious that *Amphioxus* is most fish-like and has all important features of chordate anatomy, viz. a distinct head, a dorsal flexible chord, a perforated pharynx for respiration, a circulatory system made of pulsatile heart, arteries and veins and narrow fin-folds. A few more additional improvements in the organisation and the emergence of the fish type may be said to have been completed. The first and foremost is the conversion of the notochord into the vertebral column of independent and movable discs. The second is the introduction of red blood, i.e. the addition of a red pigment which facilitates and improves the oxygen intake. This was most probably brought about by changes in the colourless iron-bearing substance, cytochrome, present in all cells and converting it into haemoglobin. The third character is the elaboration of the gill-slits and their septa into an efficient system for the exchange of gases in water. The fourth is the reorganisation of fin-fold into separate and distinct median fins and the addition of paired fins. The evolution of the fish type was thus gradual. Are there any transitional types to support this trend of conjecture? Perhaps the recent discovery in Scotland of the fossil remains of a very primitive chordate from the Silurian rocks, *Famoytius*, may well be a conservative survivor of the pre-vertebrate stock and at the same time closely related to the ancestors of *Branchiostoma* (*Amphioxus*) (Newth, 1949).

CHAPTER II

FISH ANATOMY AND STRUCTURAL ADAPTATIONS

A SURVEY of the animal kingdom shows that several sub-kingdoms (phyla) are primary denizens of either seas or rivers. The protozoans, sponges, coelenterates, arthropods (except Insects and some Arachnids), Molluscs, Echinoderms, Protochordates and Fishes all are aquatic in habits. Heavier-than-air, water presents several problems to its dwellers, such as breathing. regulation of water and salt movements to and from the body, sinking factor, movement and maintenance of stability. But no group of animals is more adapted to conditions of life in a liquid medium than fishes.

The simple lancelet (*Amphioxus*) points to the prototype of fishes. Its fusiform, bilaterally symmetrical body which is pointed at both ends is propelled by the flexure of its serially arranged blocks of body muscles. The architecture of a chordate body, is perfected in a fish. The shape and structure of a fish body, therefore, are not arbitrary but have evolved through the stress and strain of the watery environment.

The above facts can be illustrated by taking the example of a swift-swimming fish such as a shark or a mackerel. Its body is fusiform or cigar-shaped, circular or elliptical in cross-section. The head end is thicker, while the middle part gradually tapers to a thin caudal end. The general outline or contour of the body is, therefore, one of smooth continuity, without demarcations and irregularities or projections, which may hinder forward progression. The bullet-shaped head, with a pointed snout, the closely fitting jaws and gill covers, the laterally placed, lidless eyes are all parts in the design for smooth and swift swimming.

The skin of a fish has several adaptive features for a life in water. The skin has an abundant supply of mucous glands, which constantly pour their secretions and make the skin slimy. The slime helps to decrease the friction between the body surface and water, besides providing a protective coat against disease-causing germs.

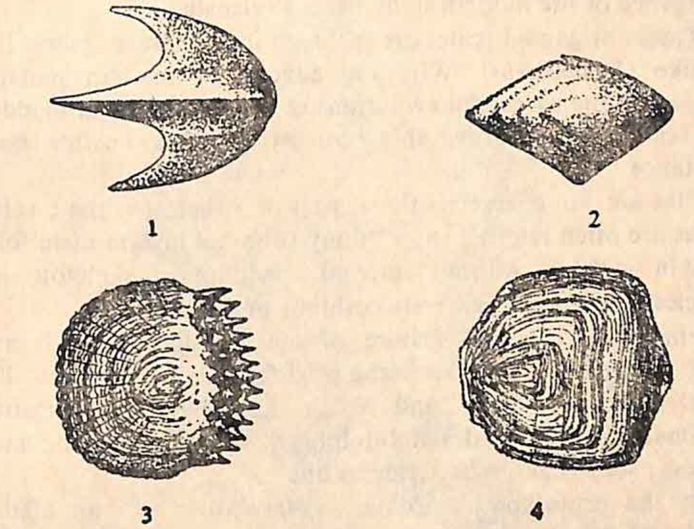


Fig. 8: 1—Placoid Scale; 2—Ganoid Scale; 3—Ctenoid Scale; and 4—Cycloid Scale.

One of the hallmarks of fishes is the presence of scales, produced by the combined effort of the deeper (dermis) and the superficial (epidermis) layers of skin. Thus a fish scale differs from a reptilian scale, which is purely epidermal. In the modern bony fishes, the scales are thin, round and overlapping, offering practically no resistance in swimming. These scales are called cycloid or, if they bear microscopic comb-like teeth, they are referred to as ctenoid. In sharks, the scales (placoid) are very minute teeth-like spines and can be seen only under a microscope. It is interesting to note that the earliest ancestors of fishes, the Ostracoderms and Placoderms, the so-called armoured fishes, were completely encased in heavy exoskeleton of bones. In a well-established group of Placoderms, the Acanthodi, the skin has an armour of ganoid scales set in mosaic. This rigid outer exoskeleton would have restricted the movements of the fish, which otherwise had acquired all the necessary features, such as shape of body and fins, so very necessary for successful living. These heavy scales persisted upto the beginning of the emergence of the modern bony fishes (Teleostei).

Traces of ganoid scales are still seen in some rare fishes like garpike (*Lepidosteus*). With the advent of modern patterns of fins and the successful evolutions of the closed swim bladder, the scales also became thin, consisting of a flexible bony substance.

Fins are so characteristic a part of fishes, that these vertebrates are often referred to as 'finny tribes'. Fins are mere folds of skin with or without internal padding of skeleton and muscles. Some fins are merely cushions of fatty tissue.

Fins are an essential feature of most aquatic animals and have evolved in response to the need for balance in water. The larval stages of frogs and toads and even the terrestrial mammals, like the whales and dolphins, which re-entered water, possess paddle-like limbs acting as fins.

In the prototype chordate; *Amphioxus*, an undulating membrane serves the function of fins. The earliest ancestors of fish, the armoured groups went a step further. They possessed well-defined caudal and dorsal fins. It was in sharks and bony fishes that the paired fins, pectoral and pelvic, became a functionally important set of organs.

Some years ago, a French scientist performed a very simple experiment to demonstrate the effect of water on a moving object. He took plasticine models, which were drawn through water at varying speeds. These models, after prolonged trials, were observed to change their shape to that of a fish. They, however, tended to roll over when left floating. He soon discovered that by placing artificial keels, the models could maintain equilibrium. Similarly, it is inferred that nature evolved a series of wedge-shaped keels, the median fins along the margin of the body and later paired keels on the belly side. These paired pectoral and pelvic help to stabilize the fish when it rests on the surface of water.

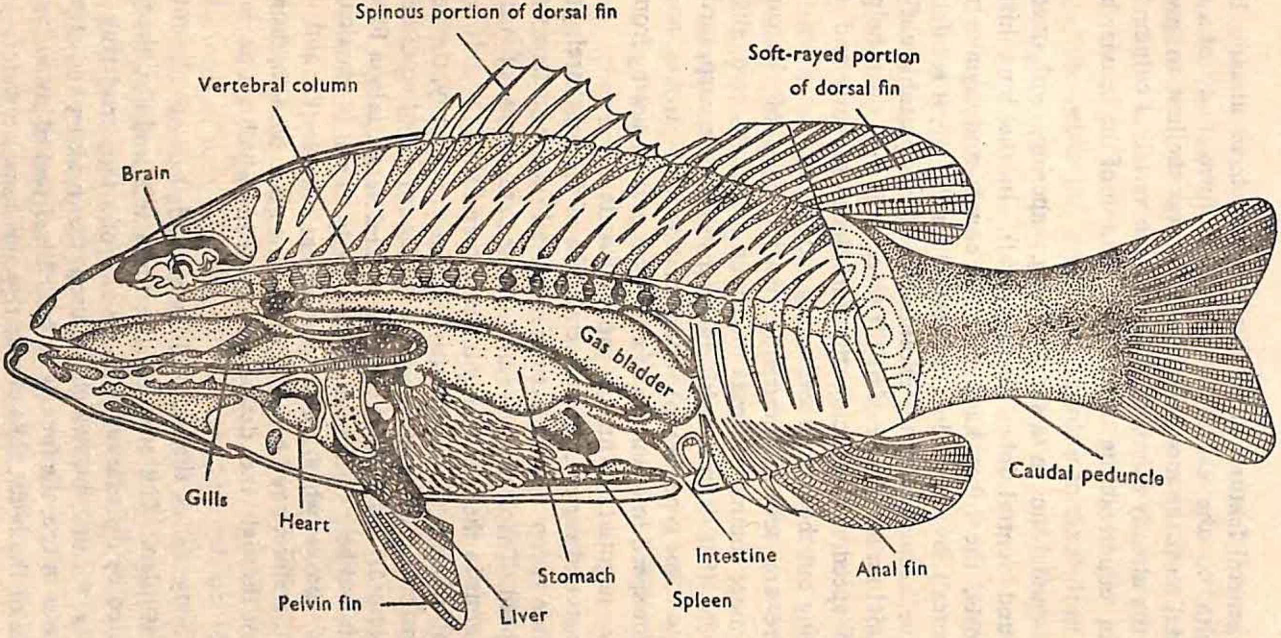


Fig. 9: A bony fish dissected to show its internal anatomical structure (*after* Lagler).

The general features of the fins of fishes have already been dealt with. In the evolution of the fusiform body of a fish, the caudal fin is the most significant. It was the first to evolve around the already existing tail end of the vertebral column and helped in counteracting the sinking motion of the heavier head end, as in the case of a shark.

The caudal fin in a shark is long, tapering, with unequal dorsal and ventral lobes (heterocercal). In the long history of teleosts, the lobes have become equal and symmetrical (homocercal) by a gradual process. This change, it is inferred, may have accompanied the evolution of the adjustable airfloat. The caudal fin is relieved of its lift force and may just help in forward speed, in reducing the turbulence of water and thus smoothing out the overall swimming action.

There are several interesting modifications of the caudal fin. A more common form is the round or square and slightly forked fin that is met with in most fishes as in carp, sardine, trout, etc. This type is well suited for powerful strokes and is suited for speed in moments of chasing a prey or fleeing from an enemy or negotiation through rapid currents.

The second variety, the crescentic fin of the mackerel, provides a wide sweep enabling the fish to sail in the surface waters with speed. There are several intermediate types of various descriptions in the large array of teleostean fishes.

In all modern fishes, both cartilaginous and bony, the paired fins constitute important organs in locomotion and equilibrium. The pectoral fins, more prominent and large, take a forward position and help to keep aloft the body. This is particularly true of sharks which have no airfloat. In sharks and their allies, therefore, equilibrium is maintained not by a hydrostatic float but through the device of their fins which act as lateral planes.

In bony fishes, the pectoral fin is modelled on an entirely different plan. The web of the fin is thin and flexible and is supported by delicate rays like the ribs of a fan, rendering high mobility to the fin, which is used for braking and steering. When not in use, the fin can be folded and tucked away against the side of the body, thus eliminating resistance to water.

The pelvic fins are comparatively small and act as additional or secondary elevating planes, when necessity arises. These are placed well behind the pectorals, usually about the middle of the body in primitive groups. In the more advanced orders, where the swim-bladder is a closed adjustable organ of equilibrium, the pelvic fins are placed forward. They may be located in the region of the chest or sometimes even in the throat.

The dorsal and anal fins constitute the median type. They arise as median folds of skin along the dorsal and ventral mid-axis of the body, respectively, and are supported by a series of simple skeletal rays. They differ from paired fins in the absence of supporting girdles or arches. The dorsal fin, which was originally a continuous one, had broken up into an anterior half and a posterior half, leaving a gap in between. In some cases, only one, usually the anterior half, persists. It takes various shapes and sizes, differing from species to species.

The anal or ventral fin, as the name suggests, is found in the anal region, always behind the pelvics. It is the least significant of fins and may even be absent in some families. When present, it may take various sizes and shapes.

Both dorsal and anal fins act as stabilizing organs against the rolling (side to side motion) of the fish.

Having outlined very briefly the kinds of fins and how they help fishes in equilibrium and swimming, it will be convenient to examine some of the interesting modifications. One of these is found in the flying fishes (Exocoetidae), in which their enormously expanded pectoral fins act as wings. These fishes are a common sight in the open oceans, when they leave water, leap into the air, open their 'wings' and glide merrily along. It is estimated that a flying fish can span a distance of 200–400 metres at a speed of 10–20 metres per second.

In some of the hill-stream fishes, the pectorals are modified into sucker-like organs, enabling the fish to adhere to rocks. In the Bornean sucker (*Gastromyzon*) even the pelvics are modified. Both pectorals and pelvics are expanded and fused with one another to form an oval disc. The mudskipper (*Periophthalmus*) found in tidal waters of the tropics is noted for its habit of coming to the shore, walking and skipping about. The pectoral fins are modified, each being attached at the end of a muscular arm, appearing like the limb of land animals. In the threadfin (*Polynemus*), the pectoral fins are seen to bear 4–8 long filaments, which are actually the inner rays of the fin, separated and elongated. These filaments act as organs of touch.

A curious modification of the dorsal fin is met with in *Remora* (Echeneidae), where part of the dorsal fin assumes the structure of an oval disc, with a double series of transverse plates. The disc enables the fish to attach itself to any flat surface. It is a fascinating sight in an aquarium to see this fish suddenly darting and attaching itself by the disc and sailing effortlessly thereafter.

In the angler fish Ceratoidei, the first ray of the spinous dorsal fin located on the snout is transformed into a 'fishing line and bait'. In one of the species (*Lasiognathus saccostomia*) of angler fish, the basal part of the dorsal fin ray has been converted into a stout rod, followed by a slender line, provided with luminous bulb, and also with a series of curved horny hooks.

Have you ever watched a fish in an aquarium? Have you ever wondered how a fish poises itself so effortlessly and gracefully? How does it move about with such ease and dexterity? The answers lie in the understanding of its external and internal anatomy.

The design of its body and fins has been fully analysed. This section we shall devote to one of the unique organs, the airbladder or airfloat, which has evolved in the long history of fishes. Water is heavier than air and any animal which lives in it has to adjust itself to the principle of floatation. Several aquatic animals have tried to solve this problem. Some of the members of the lowly group of animals belonging to the Coelenterates, like the Portuguese man-of-war (Siphonophora) and their allies like *Porpita* and *Vellela*, have a gas-filled chamber on top. Even some of the marine algae have globular airsacs which help them to float.

A large majority of fishes have devised a float which is hidden within the top of the body cavity between the backbone on one side and the gut and other organs on the other side, which is the right location for a buoyant organ. The float is a silvery white bladder-like structure filled with air and therefore popularly referred to as air-bladder. The air is a mixture of oxygen and nitrogen, not necessarily in the proportion of atmospheric air. Therefore, some prefer to call it gas-bladder. Since it aids the equilibrium and movement of the fish, it is alternatively labelled as airfloat or swim-bladder.

The swim-bladder is found to be absent in extinct armoured fishes, the Cyclostomes, sharks and rays. It is present in one form or another in the lung-fishes and the modern bony fishes. It is a highly variable organ in shape, size. number of chambers, outgrowths and other structural peculiarities.

How does the airfloat work? It helps to increase the total volume of the fish in relation to total volume of water displaced to the point where its specific gravity would be unity. Ideally, therefore, a fish with such an airfloat would remain suspended in water at a particular level, Applying the laws of hydrostatics, it is easy to find out the volume of a float which would exactly balance its own weight in water. In many fresh water fishes, the float would have to occupy about 7% of the volume of the fish, although in the heavier salt water of the sea, the float occupies 5% only.

If the float helps in maintaining buoyancy, it has to be an adjustable one. How does it operate? Let us imagine that a fish is moving downwards from a particular level. The column of water increases bringing about an increase in water pressure which is exerted on the body and thus on the airfloat inside, resulting in the reduction of its volume and consequent change in specific gravity. In other words, the deeper the fish moves, the heavier it becomes. What happens when the fish moves upwards? The column of water decreases, pressure falls and the float expands bringing the specific gravity to unity.

What is the mechanism of adjustment? This is effected by adding or removing gases in the bladder (usually a mixture of oxygen and nitrogen as in air or sometimes the oxygen may be more) by one of the following three ways; first, in the most primitive float which retains a pneumatic duct (wind-pipe) with the oesophagus (gullet), the fish swallows or expels air, as the case may be, with the aid of the duct. This is rather a crude way in the sense that the fish has to come to the surface of water

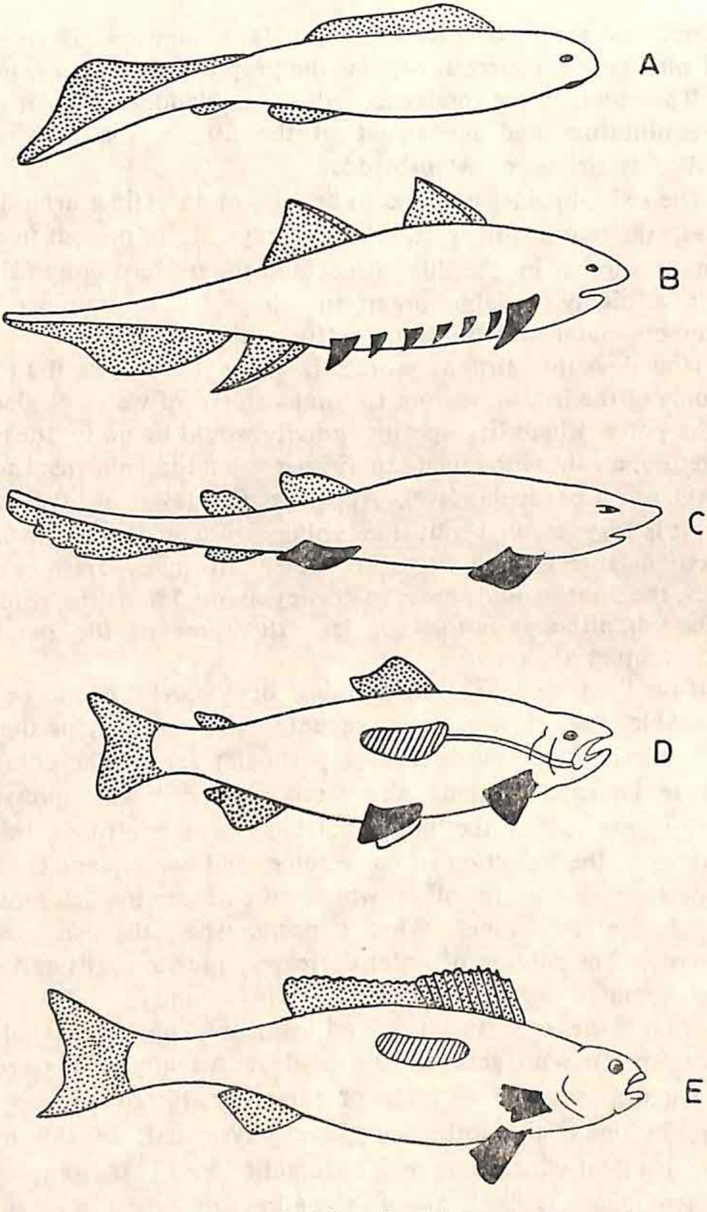


Fig. 10: Evolution of fins and airfloat in fishes. **A**—Ostracoderm stage; **B**—Placoderm stage; C—Shark stage; **D**—Early rayfin stage (sardine); and **D**—Advanced rayfin stage (perch) (*after* Lanham).

each time to refill the air-bladder. This type is known as physostomous and is met with in the lower groups of fishes like carps, catfishes and clupeids.

The second type is found in eels, whereby oxygen can be added while the fish is still under water, without coming to the surface. The oxygen which is dissolved in water is picked up by gills, transported by the bloodstream to a set of capillaries (red gland, retia mirabile) on the wall of the air-bladder. The oxygen is later secreted into the chamber. This has a definite advantage, as the fish on its ascent or descent can regulate its specific gravity with better precision. Excess gas may escape through the pneumatic duct. Periodic visits to the surface are thus avoided.

The majority of fishes have the third type, the closed or physoclistous or perfected floats. In addition to the retia mirabile or red gland, a gas gland is developed for the secretion of oxygen—the whole is a complex structure in the anterior half of the swim-bladder. Besides, there is another group of blood capillaries, the 'oval' in the posterior section, that takes the gas out. A ring of sphincter muscles around the oval controls its opening. The pneumatic duct thus becomes superfluous and is discarded in an early developmental phase.

Although the physoclistous type appears perfect, it presents certain disadvantages. The rate at which the red gland and oval absorbs or removes oxygen is so slow, that if the fish comes up from deep water too rapidly, the escape of gas is delayed and the float swells up, throwing it out of balance which then can be restored only with the effort of fins and body muscles. If the fish chooses to rise still further, it turns its belly up and is drifted to the surface. The physostomous air-bladder allows the fish to discharge air quickly through the pneumatic duct.

Some of the interesting modifications that the swim-bladder undergoes may be considered briefly. In some fishes like the clupeids, catfishes and carps, it aids hearing. Sound waves which impinge on the body of the fish are transmitted first to the air-bladder, which in the above groups maintains a connection with the ear. In clupeids, the anterior end of the bladder is prolonged into a blind sac which either lies closely adherent to the ear capsule or enters the peri-lymphatic space of the ear and gets associated with the inner ear. In catfishes and carps, a chain of bones which originate as modifications of the first four or five vertebrae and known as 'Weberian ossicles' gets linked with the inner ear on the interior extremity and the wall of the air-bladder posteriorly. Like the mammalian ear ossicles, they help transmit sound waves.

Another interesting modification is the use of the air-bladder for respiration. Fishes normally breathe through gills, but in certain tropical species, when the water gets foul in summer and oxygen gets depleted in the surrounding water, special organs capable of absorbing atmospheric air develop. One of these is the transformation of the air-bladder into a truly lung-like organ. The Australian lung-fish *Ceratodus* is the best known example, besides the African lung-fish. *Protopterus*, and the South American *Lepidosiren*.

It is of interest to note that the swim-bladder is absent in sharks and rays as well as in lampreys. It is believed that the bladder arose as a pair of saccular outgrowths of the gullet-like lungs in the higher vertebrates to supplement breathing in the fresh water fishes of the Devonian, one of the most arid and dry geologic periods. Its original function was most probably respiratory. The paired organ later became median and dorsal and assumed a hydrostatic function, when fishes radiated out to the seas.

CHAPTER III

SENSE ORGANS IN FISHES

THE SUCCESS of fishes over lowly creatures like *Amphioxus* (belonging to the *Acrania* which literally means 'headless creatures') and their domination as the first vertebrates are attributed to the development of a head with its large and complex brain and elaborately fashioned sense or receptor organs, which act as 'ports of entry'. These organs are the eyes, the ears and the nose. Besides, the sense of touch is well-developed. Over and above, there are special cutaneous sense organs which are exclusive adaptations for life in water.

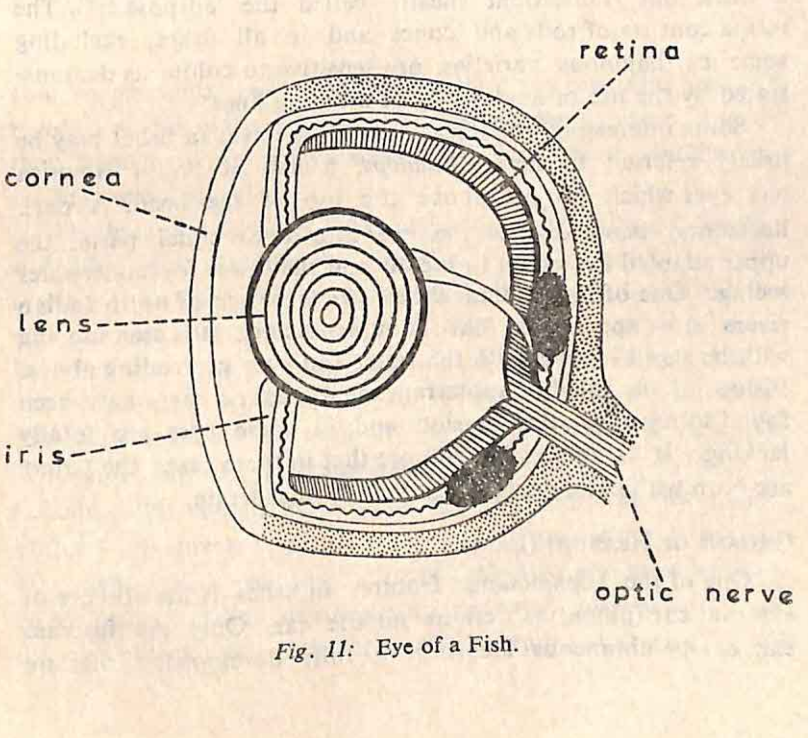


Fig. 11: Eye of a Fish.

ORGANS OF SIGHT

To a layman, the eyes are the most noticeable of sense organs in a fish. They are prominent, round, oval or elliptical structures situated on either side of the head. The eye of a fish is typically vertebrate and thus resembles our own.

The most significant point about a fish is that it has to see under water, for which purpose its eye presents minor variations. The lens is round, instead of flat or concave and the iris diaphragm has little power of contraction. The main difference lies in the mechanism of focusing. While the mammalian eye changes the curvature of the lens, the fish eye changes the distance between the lens and the retina, like an adjustable camera. The vision is monocular instead of binocular as in higher vertebrates. Fish eye is peculiar in the absence of eyelids, eyelashes and tear glands. Some sharks have a thin fold or skin, the 'nictitating membrane' which can be drawn over the eyeball. In some bony fishes, the surrounding rim of the eyeball overgrows into a thick but transparent sheath, called the 'adipose lid'. The retina consists of rods and cones and in all fishes, excluding some cartilaginous varieties, are sensitive to colour as demonstrated by the use of angler's fly of differing hues.

Some interesting modifications of the eyes in fishes may be briefly referred to here. *Anableps*, a fish of South America has eyes which project above the top of the head. A dark horizontal band divides the eye into two equal parts, the upper adapted for vision in the air and the lower for underwater seeing. One of the Indian fishes *Mugil corsula* of north Indian rivers also appears to have double vision. It is seen moving with its snout in level with the water and eyes protruding above. Fishes which inhabit subterranean waters or caves have been found to have lost their vision and in some eyes are totally lacking. It is interesting to note that in these cases, the young are born with eyes, which subsequently degenerate.

ORGANS OF HEARING (EARS)

One of the conspicuous features in fishes is the absence of external ear (pinna) as well as middle ear. Only the internal ear or membraneous labyrinth is fully developed. Fishes are

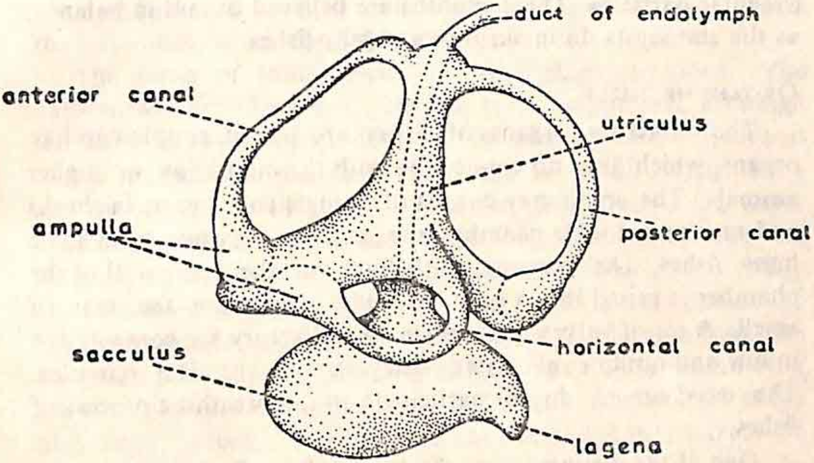


Fig. 12: Ear of a Fish.

able to recognize sound produced by their own kind and can register sound waves conducted through water more sharply than through air, as demonstrated by experiments of Parker, an American biologist.

The inner ear consists of two portions: (i) a fluid-filled bag is divided into utriculus and sacculus. The utricular portion receives the three semi-circular canals; (ii) extending from the utriculus and intercommunicating with it, is sacculus with its blind diverticulum, the lagena. It will be noted that a fish is devoid of cochlea. which is characteristic of mammals. The utriculus and the semi-circular canals constitute the organ of balance and the sacculus-lagena complex that of hearing. Certain calcareous particles which aggregate into stones called otoliths are present in the ear of a large majority of fishes. In bony fishes, these are usually three in number and are identified as *sagitta* in sacculus, *asteriscus* in lagena and *lapillus* in utriculus. In sharks and rays. the otoliths are a cluster of small irregular particles. These otoliths are believed to aid in balance, as the statocysts do in shrimps and jelly-fishes.

ORGANS OF SMELL

The olfactory organs of fishes are paired, simple cup-like organs, which have no connection with the mouth as in higher animals. The organ may consist of a single chamber as in sharks and rays or a double chamber, separated by a septum, as in some bony fishes. The mucous epithelium on the inner wall of the chamber is raised into a series of folds, which are the seat of smell. A set of valves present in the olfactory sac controls the inflow and outflow of water, carrying the chemical particles. The nasal organs do not participate in the breathing process of fishes.

One of the distinguishing features of the Cyclostomes is the presence of a single median dorsal nasal opening, which in lampreys communicates with a blind nasal sac to form the nasal-hypophysial complex. But in the hagfishes, the nasal sac opens into the roof of the mouth.

The sense of smell is reflatively high in most fishes as proved by a number of experiments. Sharks are noted for their keen sense of smell, which enables them to detect their prey from a distance. Experiments on blinded sharks have shown that they can locate food with the help of smell alone. Salmon is endowed with an uncanny sense of smell. It is able to recognize the particular stream in which it was born, when it returns from the sea to fresh water for spawning. Dr. Hasler of the U.S.A. has done a great deal of research on the 'Homing Instinct of Salmon' and he opines that it is the power of smell that enables the ascending salmon to locate the particular stream or river of its birth.

Besides the receptor organs of sight, hearing and smell, reference may be made to the sense of taste and touch.

The sense of taste in usually associated with the tongue, but fishes have no tongues in the true sense. In some, like the shark, the basihyal element of the branchial skeleton has a conical projection, which supports the oral membrane and gives semblance to the tongue. The mucous membrane of the mouth, lips and barbels is studded with clusters of special sensory cells, the taste buds, which form the organs of taste.

The sense of touch seems to be highly developed. The barbels, whisker-like organs, are the most important, although the skin around the mouth and the snout is also sensitive to touch. Barbels are not necessarily present in all fishes. They are prominent in the catfishes, some carps and a few other orders of teleosts. They are highly variable. They may be long or short, rounded or flattened, smooth or rough. They are associated generally with the mouth, the under surface of the head and the mentum or chin region. Catfishes afford the best examples. They have long whisker-like feelers numbering 2-8 from which the popular name is derived. Some of the carps also have barbels but they are shorter and fewer. Barbels of oceanic and deep-sea fishes take bizarre forms. They may be very long, about one-and-a half to two times the length of the fish and look like fishing rod and line. Some of the barbels are branched and look like weeds attached to the chin. One of the remarkable examples of specialised organs of touch is met with in a group of sea fishes known as 'threadfins' (Polynemids). The first few rays of the pectoral fins are separate from other rays that support the web of fin and become long and filamentous. In one of the Indian examples of threadfins, these filaments of the pectoral fins are numerous and extend beyond the length of the fish, suggestive of the beard of a sannyasi (monk) so that popularly it is called 'Tapasi fish.'

The essential organs of touch are clusters of special sense cells, not unlike the taste buds of the mouth.

SPECIAL CUTANEOUS SENSE ORGANS

(i) *Lateral line sense organs*

One of the problems that a fish faces in its habitat is adjustment to density, pressure and currents of water. A characteristic set of sense organs, found nowhere else in the animal kingdom (except in the aquatic larval stages of Amphibia and certain groups of adult Amphibia which are perennial dwellers of water) are found in fishes. These are the lateral line system of the neuromast organs of Wright. It is interesting to note that the

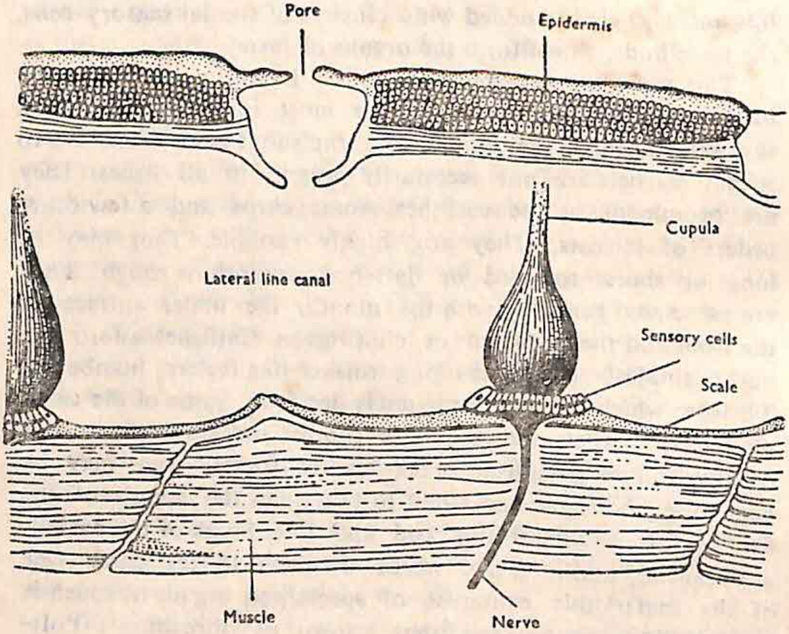


Fig. 13: Neuromasts in the lateral line system of a bony fish (*after* Grasse).

oldest members of the fossil fishes also showed traces of these organs. This points to the fact that fishes, from their first emergence, evolved a special kind of skin receptor organs in response to the watery environment.

The lateral line system is composed of a very narrow canal situated in the skin and running along the middle of each side of the body from tail to head. In some bony fishes this is visible to the naked eye as a pencil mark. Anteriorly, near the gills, each canal branches into a complex system of smaller canals running in a definite pattern on the dorsal, lateral and ventral surfaces of the head. The canals arise from the epidermal cells of the skin into which they sink. In most of the primitive fishes, the canals are merely grooves and are thus open, while in more advanced groups, they become closed and lie buried deep in the outer layer of the skin. The lateral line system is easily seen in a cartilaginous fish, for example, in rays, which are without any scales. In the allied fish—the sharks, the system can be seen with careful removal of the skin by a sharp scalpel or knife. In bony fishes, the main lateral line canals of the trunk are visible but those on the head are hidden on account of the bones that develop in the skin. All the canals are filled with mucus, so much so that the early biologists believed them to be mere mucous canals. Microscopic studies of the skin later revealed the presence of clusters of cells, very much like the taste buds, which later were referred to as neuromast organs of Wright, after their discoverer. Neuromast organs are arranged regularly at intervals along the course of the canal and are bathed by mucus. These organs consist of two sets of cells; first, the specialised cutaneous receptor cells and second, the supporting cells. The neuromasts are innervated by sensory nerves belonging to the seventh, ninth and tenth cranial nerves.

The main lateral line and the cephalic canals give off at intervals short vertical shafts each of which opens to the outside by a minute pore. These are easily visible in sharks and rays. It is believed that low frequency vibrations coming from the surrounding water impinge on the fish body and exert pressure on the mucus, which in turn excites the neuromast organs. The sensory impulse thus set up travels along the nerves to the brain.

What specific functions does the lateral line system perform? The question has intrigued a number of biologists. Since they are present only in the aquatic vertebrates, it is natural to think that they relate the animal to the watery medium. Experiments have shown that the neuromast organs are not stimulated by heat, sound, light, chemical particles, electricity and salinity or ordinary water pressure or strong currents. The only stimulus they react to is 'vibrations of low frequency'. This was later confirmed by the Dutch zoologist Dijkraff, by the use of a highly sensitive apparatus (oscillograph). From the results of the experiments conducted during the last hundred years, it may be concluded that these organs help to detect water currents of low frequency, and the sense organs are of the nature of 'rheo-receptors'. In other words, the waves on the surface of the water produced by air currents or disturbances made by bodies falling into the water produce vibrations that stimulate the lateral line system. No doubt that this sense of movement in the water is peculiar to fish and enables them to have a 'watery-touch'.

Short references may be made to two more sets of cutaneous sense organs. These are the ampullae of Lorenzini and pit-organs. They occur only in the cartilaginous fishes.

(ii) *Ampullae of Lorenzini*

Ampullae of Lorenzini resemble the neuromast organs of the lateral line system in the nature of their structure and histological features. An ampulla is an orange-shaped body, made up of 6-8 parts and a short or long canal, opening to the exterior by a pore. Several hundreds of ampullae cluster together. In rays such as sting ray (*Desyatis*) clusters are distributed at 3 definite centres on the head region. They are (a) superior ophthalmic, above the eye, (b) buccal, anterior to the mouth and (c) hyomandibular, in front of the gill region. In sharks, for example *Scoliodon*, only two groupings are met with, the buccal and superior ophthalmic. The ampullae are innervated by the branches of the seventh cranial nerve.

The canals of the ampullae are filled with mucus. Their function baffled many a scientist for a long time. As their structure and nerve supply resemble the lateral line system, it was conjectured that their function also may be similar. It was not until 1936 or so, the suggestion that they may serve a different function arose in the minds of physiologists. Sand and Lowenstein, two British scientists, took up series of electro-physiological experiments by oscillograph on sharks and rays. Initially they detected a rhythmic, spontaneous activity in the ampullary canals. Later they subjected the fishes to various kinds of stimuli like pressure, salinity, water-flow, heat, cold, electric current, etc. By analysis of the various data, they detected that these organs react to temperature variations. Paradoxically, heat retards while cold accelerates their action. Also, these organs are most sensitive in the range between

3°C and 25°C. The authors therefore concluded that the ampullae of Lorenzini are thermo-receptors.

The above view was questioned by later scientists. What is the use of these deeply sunk organs to heat regulation or sensitivity to a fish—a coldblooded animal? Murray and Dijkraff (1967) again carried out experiments on some Elasmobranch fishes. They subjected the fishes to electrical stimuli of various intensities. Their observations led them to believe that the ampullae are extremely sensitive to electric current even to very minute degrees like as when the heart of a nearby fish beats. Reactions to heat or cold are merely side-effects.

Around 1976 a group of Russian scientists at the Pavlov Institute in U.S.S.R. showed by experimental studies that 'the ampullae of Lorenzini also respond in changes of magnetic field, similar, in fact, to those produced when the fish moves about normally in the Earth's magnetic field. From various characters of the response, it seems likely that the effective stimulus is the electromagnetic force produced by magnetic flow across the fish's body. The added bonus of directional sensitivity with some receptors only firing in a certain orientation to magnetic north, means that in theory at least, the fish can use its built-in compass as an aid to orientation. (*New Scientist*, May 1976).

To sum up, ampullae of Lorenzini show responses to temperature, water currents, fluctuations in electricity and possibly magnetic flow in the surrounding medium. These research findings point to the striking feature that these deeply-sunk cutaneous organs innervated by cranial nerves emanating from the medulla oblongata (hind-brain) are of a complex nature. That they occur in cartilaginous fishes only is more intriguing. If these fishes originated earlier than the bony fishes, these cutaneous sensory organs had a specific function in the murky waters of the Devonian era of the earth's history.

(iii) *Pit Organs*

The second group of cutaneous sense organs peculiar to cartilaginous fishes is called the pit organs. In sharks, where the skin in covered with minute placoid scales, the pit organs lie in shallow, round depressions in the skin epithelium, shielded by the denticles of the scales. They are found on the dorsal and ventral surfaces of the head region. In rays, where the skin is naked, these cutaneous sense organs are clearly visible to the naked eye. They are serially arranged on the dorsal surface of the disc-shaped body along each side of the vertebral column from behind the gill region to the middle of the tail. The ventral surface on which the fish lies is devoid of any pit organ.

Each pit organ is bud-like, round or oval in shape and arises as modifications of the epidermal epithelium. They are similar to the neuromasts of the lateral line system. Each pit organ is composed of two rows of cells. The outer row consists of supporting cells and the inner row of sensory cells, bearing delicate hairs which form a brush like cluster or cupule, supplied with fine nerve fibres of the lateralis branch of the tenth cranial nerve.

What function does the pit organs play? Although they resemble taste buds, they do not seem to take on the function of taste or smell owing to their location. They seem to be additional organs of current receptors, enabling the fish to have a sense of distant touch like the neuromasts of the lateral lines.

CHAPTER IV

BREATHING ORGANS IN FISHES

ONE OF the distinguishing features of fishes is their ability to breathe oxygen dissolved in water by means of gills. Gills are feather-like organs, richly supplied with blood capillaries for the exchange of oxygen and carbon dioxide. They are found in the pharyngeal region of the gut and are bathed by water currents drawn through the mouth. This is a fundamental chordate pattern, as seen in *Amphioxus* and other lowly chordates, where the gill system consists of a long series of perforations

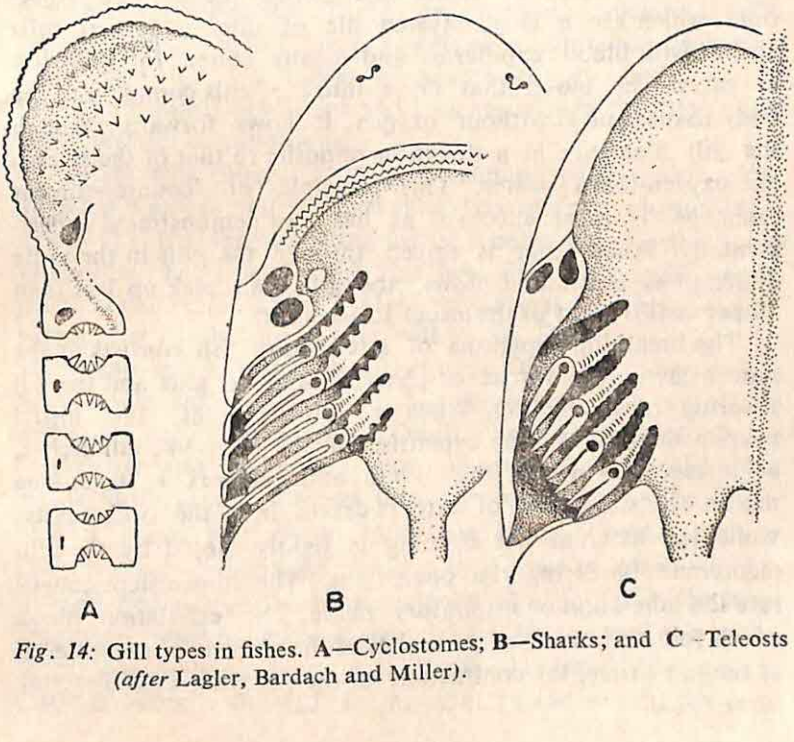


Fig. 14: Gill types in fishes. A—Cyclostomes; B—Sharks; and C–Teleosts (*after* Lagler, Bardach and Miller).

of the pharynx, the vascular wall of which absorbs oxygen from the water current, which is shifted out to the exterior.

In the earliest jawless fishes, the number of gill-slits is smaller and special pouches, encircling bundles of leaf-like gill plates, were refined as in modern lampreys and this class of fishes came to be known as Marsipobranchii, meaning 'pouched-gilled'. As jawed fishes evolved, the number of gills was further reduced. Sharks have usually five, rarely six or seven gills. Bony fishes have four gills or may be cven less. Further, the pouches are dispensed with and the gills are borne on a skeletal frame-work called gill or branchial arches.

In a bony fish (teleost) there are usually four gills on each side of the pharynx or throat. Externally they are protected by a cover (operculum). The functional part of the gills consists of filaments, thin, delicate and gorged with blood, which are arranged in two rows, anterior and posterior, on the gill arch. Each filament bears on either side microscopic leaf-like projections, which are a single-layered file of thin epidermal cells packed with blood capillaries and ideally suited for diffusion of gases. The blood that flows into the gills comes from the body tissues and is without oxygen. It flows forward through the gill filaments in a direction opposite to that of the stream of oxygen-laden water. This principle of 'counter-current exchange' is most effective, as has been demonstrated experimentally. When water is forced through the gills in the same direction as the blood flows, the gills can pick up less than 10 per cent instead of the usual 15 per cent.

The breathing apparatus of a teleostean fish consists of the mouth cavity, the throat or pharynx with its gills and the gill covering or operculum. When a fish breathes, the initial movement consists of an expansion of the hoop-like gill arches, as a result of which the mouth and pharynx enlarge. The mouth opens, a stream of water is drawn into the oral cavity, while the external gill opening is tightly closed by the thin membrane bordering the operculum. The above steps constitute the inhalation or inspiratory phase. The exhalation phase which follows immediately consists of the closure of mouth and, at the same time, the contraction of the pharynx, thus directing the water towards the gills and thence through the operculum. The pulsatory movement of the opening of the mouth and operculum, alternated with their closing, is easy to watch in a fish in an aquarium. Although a fish has a pair of nostrils, these latter do not have any connection to the mouth and therefore do not take part in respiration. They are mere olfactory or smell organs.

Beyond the gills, the blood is collected by an efferent system of arteries draining into the main dorsal aorta, which distributes blood to all tissues. Relieved of its oxygen the blood returns to the receiving chambers of the heart, the sinus venosus, which opens into the auricle. The auricle sets up pressure, so that blood can be forced into the highly muscular ventricle, which pumps the blood by afferent arteries to the gills.

Fish blood, like that of any other vertebrate, consists of a fluid substance, the plasma, in which float minute cells, the red and white corpuscles. These are circular, nucleated cells, the cytoplasm of which has a remarkable substance, haemoglobin, which has the power to absorb oxygen under certain physico-chemical conditions and later to release the same under a different set of conditions.

Fishes with lungs! That may sound paradoxical. Yet, there are a few examples which show this curious phenomenon. These are the famous 'lung-fishes', belonging to the class Dipnoi or Dipneusti, which has been dealt with under appropriate classification already. Here the special breathing organs, which exist in addition to gills, will be considered.

The so-called 'lung' in the Australian Dipnoan, *Neoceratodus*, is a single spacious sac, which extends from one end of the abdominal cavity to the other. On its inner surface, along the mid-dorsal and mid-ventral axis, run two longitudinal fibrous bands which project slightly into the lung cavity. The longitudinal bands give rise to transverse bands or septa on either side, thus sub-dividing the cavity into a series of alveoli, which in turn are sacculated by a network of fine ridges. The lung, through a pneumatic duct, opens into the ventral side of the gullet or oesophagus by a small glottis. Air enters through the external nostrils situated at the edge of the mouth, passes to the internal nostrils on its roof and then through the pneumatic duct to the long cavity. *Neoceratodus* comes to the surface to breathe air. During draught, it is able to survive in foul water, which kills other fishes.

The African lung-fish, *Protopterus*, and the South American lung-fish, *Lepidosiren*, have more or less identical modifications. The lung is double, consisting of two sacs running along the whole length of the coelom and reaching upto the cloacal opening. The two sacs unite anteriorly into a median sac or vestibule which acts as the pneumatic duct, communicating with the oesophagus by glottis. Glottis is controlled by a set of radially arranged muscles. An epiglottis also is found in these fishes, Each lung sac cavity is further divided into a series of irregular alveoli, some large and others small. The alveoli sub-divide into tubules which terminate finally into very small pockets. Thus, it would be seen that these two lung-fishes approach, in their lung-structure, the terrestrial vertebrates.

From ancient times, people have observed that certain fishes can live out of water. The fresh-water eel (*Anguilla*) wanders out on the meadows in the night. In the tropics, the snake-heads (*Ophicephalids*) can survive on land. The climbing perch (*Anabas*) is believed to leave water and climb up palm-trees in the tropical swamps. To the ancient naturalists, these were curious fishes which seemed to possess 'some secret way' which enabled them to breathe on land, unlike the vast majority of fishes which are incapable of living even for a few minutes out of water.

Studies on the anatomy of the above-mentioned fishes and their allies have now solved the mystery. They are found to possess special organs and devices which enable them to take in atmospheric air, when they leave water and wander on to the land.

Eels are able to survive for a considerable time away from their natural surrounding and wander over dewy meadows in the cool of the night, seeking new streams and rivulets. It has now been established after considerable research, that it is the skin that performs respiration on land. The skin of eels is almost naked, the scales being minute and buried inside, besides being highly slimy and vascular. All these characteristics enable the skin to function as an efficient accessory organ of breathing.

In the majority of fishes with one or another type of accessory breathing organs, it is the buccal or pharyngeal cavities that are natural locations for such modifications as they lie in the respiratory tract. In the snake-heads (*Ophicephalids*), a pair of hollow pouches develops on the roof of the mouth on either side of the plate. These pharyngeal sacs have a large number of nodules or papillae richly supplied with blood vessels, which help in retention and diffusion of gases. These fishes are called *Murrels* or *Warrals* in India and are a common sight in fish bazaars, where vendors keep them in mud pots and sell them as 'live fishes'.

The familiar catfish, *Clarias*, of our ponds and paddy fields, has two pairs of fascinating organs. Under each gill cover and lying appositely to the gills are a pair of tree-like organs. They are tufts of epithelial outgrowths from the gill arches and are supplied with a network of blood vessels. These fishes thrive in swampy areas, as long as the water level is adequate. But in summer, when water dries up, the gills are not effective for aquatic respiration. The fishes then come up to the surface and breathe through their tree-like respiratory organs.

Another variation of the theme is met with in the Indian catfish, *Heteropneustes* or *Saccobranchus*. It develops on either side of its pharynx a diverticulum, which excavates the lateral body muscles and extends almost to the tail end in the form of a hollow, tubular lung, which can retain air and diffuse it to the blood channel.

The climbing perch, *Anabus*, was first introduced to the scientific literature in a memoir (1797) by Daldorf, a lieutenant in the service of the Danish East India Company at Tranquebar. The fish derives its name from a popular belief that it climbs palm-trees and drinks its juice, toddy. It can, however, traverse land and breathe air. The organs concerned are rosette-shaped structures made up of a number of concentrically arranged shell-like plates, with wavy edges. These are outgrowths from the branchial arches and are richly supplied with fine blood vessels.

The most perfect form of accessory respiratory organ is found

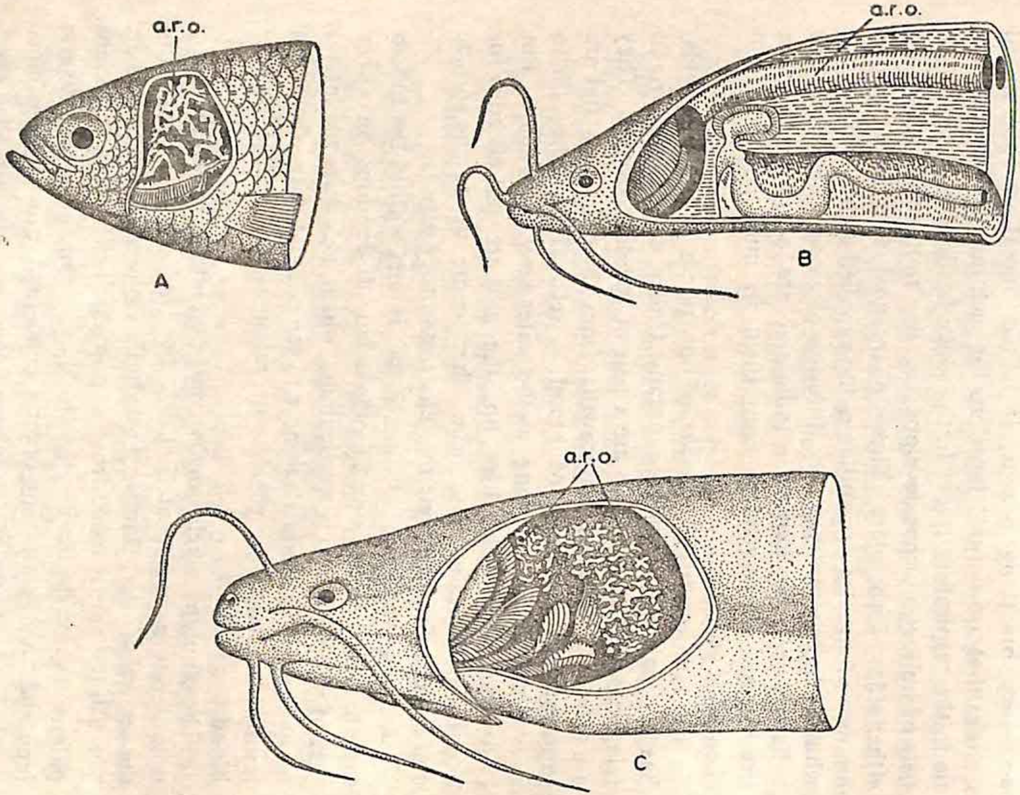


Fig. 15: Accessory of respiratory organs of fishes. A—*Anabas* (climbing perch) showing rosette-like organs (a.r.o.); B—*Heteropneustes*. Lung-like pharyngeal sac (a.r.o.); and, C—*Clarias*. Tree-like organs (a.r.o.) (*after* Norman).

in a North Indian fish, the cuchia eel (*Amphipnous*) found in the rivers of Bihar and Bengal. It is limbless and eel-like, but scientists do not consider it as a true eel. It spends most of its time in the grass on the banks of ponds. The air-breathing organs consist of a pair of sacs, growing out of the pharynx above the gills. The gills themselves are rudimentary and the fish has evidently lost all its power of aquatic respiration. It frequents the surface of water at frequent intervals to inhale air into its 'lungs', which are very similar to those of a frog.

In a few teleosts the air-bladder under special circumstances has been secondarily modified as an accessory respiratory organ. One of the noted examples in India is the chital fish, *Notopterus*, a distant relation of sardines belonging to the big order of clupeid fishes. It has an open air-bladder (physostomous), which is similar to a vertebrate lung. The main portion of the air-bladder lying in the abdominal portion of the body cavity bifurcates into two lateral bronchi-like tubes. Each of these extends beyond the abdomen into the trunk, penetrates the muscles, where a series of 14 or 15 blind pouches with finger-shaped processes are met with. The pouches and their processes are supplied with a profuse supply of blood capillaries and recall the appearance of bronchi and alveoli of a mammalian lung. The fish has great tenacity to stay out of water, sometimes as long as two hours or more. When kept in an aquarium, it rises to the surface periodically and gulps air. Experimental drowning and analysis of the gases of the swim-bladder have confirmed that *Notopterus* is almost a total air-breather. Its gills are small and reduced and if it is denied access to atmospheric air, it is asphyxiated.

CHAPTER V

ELECTRICITY, BIOLUMINISCENCE AND VENOM

ELECTRIC ORGANS

MAN IN his ingenuity discovered electricity such as exists in clouds or waterfalls. Later, he invented elaborate machines to generate electric power. But in the world of living beings, fishes are the only creatures which have evolved a 'living battery'.

Fishes which possess electric organs are found among both the cartilaginous and bony fishes. Among the former are the well-known rays such as Torpedo, Narcine and Astrape while in the latter mention may be made of the Mormyrids of Africa, Electric eels, Electric catfishes and Star-gazers.

In the torpedo, the electric organ lies on each side of the disc-like body, between the head and the pectoral, fin, which circles round the body. Each organ is a conspicuous whitish body made up of a number of upright hexagonal tubes or columns separated from one another by walls of fibrous connective tissues, Each column is filled with a clear jelly-like substance and is further sub-divided by thin partitions into a number of small compartments, each containing a flat electric plate. On one side of the plate is a cluster of fine nerve tendrils, which unite and join the main nerves, supplying the organ, viz. the ninth and tenth cranial nerves. The side of the plate with nerve endings is the negative, while the opposite is the positive pole. The current passes from the positive to the negative. Coates of New York Aquarium and Cox of New York University, who did a great deal of experimental work on electric rays, measured the force of the electric current discharged by means of an oscillograph. They observed that initial outflow was 220 volts and after a minute the charge dropped to 60 volts and that both right and left organs discharge simultaneously.

In the electric eels (*Electrophorus*), there are two organs on each side of the tail, a large upper one and a small lower one along the base of the anal fin.

The electric organ of the catfish (*Malapterurus*) consists of a sheath of gelatinous material and lying beneath the skin and muscles enveloping the whole of the trunks.

In mormyrids, the electric organs are rudimentary. They are situated on either side of the terminal portion of the tail. In the star-gazer (*Uranoscopus*), the electric organs are situated on the head. Behind each eye is seen an oval sac, made up of many layers of electric plates and complicated in their arrangement. They are powerful organs and are capable of inflicting intense and painful shocks.

How are these 'living batteries' fashioned in fishes? It is now known that electric organs, in general, are modifications of muscles. In the torpedo, each electric plate is nothing more than a transformed muscles fibre. As the electric organs are related to the gill region, it is the branchial muscles attached to the gill arches that get transformed into the electric plates. In the electric eel, skates and mormyrids, the lateral body muscles of the tail are modified. Curiously enough, the eye muscles are involved in the formation of the electric organs in the star-gazer.

J. Richer, a Frenchman (1729), gave the first account of the electric eel and its behaviour. He reported that the shock was strong enough to knock down and kill a horse, that the fishes could discharge electricity at will, and it is no safer or any more pleasant for the man or beast to come into contact with them than to run into an uninsulated wire. Coates (1939) after four years of research added a number of interesting facts. By the use of a cathode ray oscillograph, which was connected by wires along the ventral and dorsal surface of an electric fish, he traced on a screen the impulse fed into it. These were photographed and later compared with recordings of electric impulses of established values. Thus, it was found that though the voltage may vary with each individual, the average-sized one discharged about 550–600 volts. This rate is seen to fall after repeated discharge. It was also observed that the impulse travelled at the prodigious rate of about 1,220–1,525 m per second. This is estimated at about 12–15 times faster than the rate of travel of impulses along nerves to and from the brain in man.

What is the use of these unique organs to the fishes? From accounts of various incidents, it is now known that the shock inflicted is dangerous, if not fatal, to man. Fishes use these shocks to stun other fishes which fall a prey to them. The electric organs, besides being organs of offence, may also act as defensive organs. There are a number of interesting tales about them from South America, Africa and India. Men and beasts are reported to have been knocked down when they had trodden upon electric eels, which had lain buried in shallow water.

BIOLUMINISCENCE (Animal light)

The ability to produce light without heat is a rare phenomenon and is met with in a few cases of living organisms. Well-known examples are the glow-worm or fire-fly, so common in India and certain wasps of South America. In the sea also are found certain protozoans (*Noctiluca*), certain jelly-fishes or medusae, comb-plates or ctenophores and shrimps (*Crustaceans*) which have a light-producing mechanism. But it is in fishes that bioluminiscence has reached its perfection. The great majority of deep-sea fishes living at depths of 90-550 m or more have evolved light-producing organs or photophores which are varied in kind, number and origin.

Among the cartilaginous fishes, a few deep-sea sharks belonging to the order Squalidae emit light which is vividly greenish in colour, with a phosphorescent gleam produced by numerous simple, tiny light organs all over the skin.

It is in the bony fishes that we meet with a large variety of light organs. One of the well-known examples is the wide-mouths (*Stomiatoidea*), inhabitants of the open ocean. These fishes have two rows of photophores on either side of the body, one row on the belly and another above but parallel to the first row. The two rows run from head to tail and the photophores appear to be metameric. Each organ consists of a group of gland cells which are shaped like a cup. The inside of the cup has a lining of black pigment to form a reflector. The mouth of the cup has a diaphragm supporting a lens. The gland cells emit light which is reflected through the lens. It is a fascinating sight to see a series of lights on the latero-ventral sides of the fish, like an oceanic vessel with its lighted port-holes.

Myctophids (lantern fishes), as the name suggests, are an important group of deep-sea fishes with little lanterns or lights. These light organs are fewer in number, but are larger and brighter, having the appearance of glistening jewels or mother of-pearl buttons, which have a symmetrical arrangement on the lower parts of the body.

The most intriguing question is—what is the mechanism of the production of light in animals? That it is a bio-chemical process is now well established. The slime or jelly produced by the skin elaborates a substance containing phosphorus, where oxidation produces a glow. In the case of photophores, where gland cells are present, it is found that they secrete a substance known as *luciferin* which in the presence of an enzyme *luciferase* is converted into oxy-luciferin, which results in emission of light.

What are the uses of light-producing organs to these animals? The most obvious use is to provide light in places of darkness as in the deep seas; where ordinary sunlight does not penetrate. They are also used as defensive organs to confuse the enemy as in lantern fishes. A further use may be as recognition marks for individuals of the same species like spots and stripes. They also act as lures for prey as in angler fishes and wide-mouths.

VENOM IN FISHES

Venom in fishes is of two kinds. One kind of venom is produced by specialised glands which may occur in various parts of the body. In the second, the flesh itself may secrete some toxic substances and the fish becomes poisonous and inedible.

There are several examples of poison glands in cartilaginous fishes. These glands are usually associated with a spine or sting, as in the cases of spiny dogfish (*Squalus*) or bull-head shark (*Heterodontus*), sting ray (*Trygon* or *Dasyatis*), eagle ray (*Myliobatis*) and king of herrings (*Chimaera*). From earliest times, it has been reported that a sting by any of the above Elasmobranch fishes leads to pain and later to inflammation.

It was first suspected that the cause lay in the mucous substance covering the spine which inflicts the wound. Pliny, the Roman scientist, attributed it to bacterial infection, which follows the wound. It is now established that there are special cutaneous glands associated with the spines which are capable of secreting poison. These glands often lie at the base of the spine. However, in the sting ray, the poison glands are seen to lie along a lateral groove on each side of the spine on its tail. As the spine drives itself into the flesh of the victim, the venom pours from the groove into the wound, resulting in pain and numbness.

There are a few well-known examples of poison apparatus amongst the catfishes, weavers, scorpion fishes and toad fishes, all belonging to the bony group. In the North American catfish popularly called Mad-Tom (*Noturus*), the outer ray of each pectoral fin is modified to form a stout, flat spine, serrated along one or both of its edges and capable of inflicting wounds. At the base of the spine is a sac believed to contain venom. In the weavers (*Trachinurus*), the spine, located on the gill cover, is ensheathed by an extension of the skin, with only its tip projecting. A deep groove bordered by a mass of glandular tissue runs along on either side. No duct is present and it is believed that venom may just flow out by the rupture of the poison gland cells. Weaver-fish venom is virulent and causes an acute burning

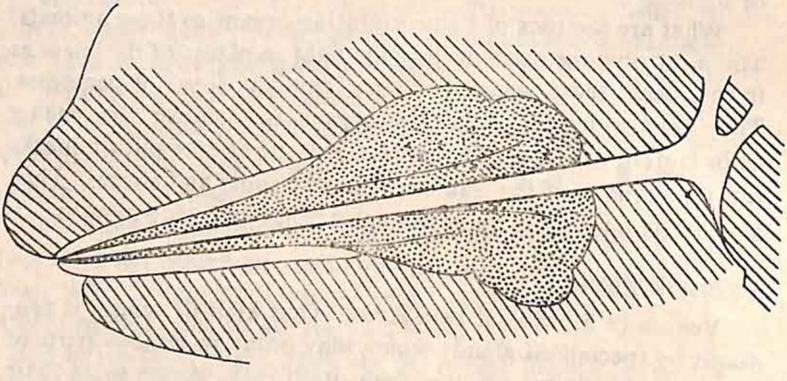


Fig. 16: Poison spine and gland of *Trachinurus* (weaver-fish) (*after* Norman).

pain, palpitation and even fainting. Dr. Evans, who has done a great deal of work on the poison apparatus and poison among animals, has recommended that an injection of a few minim of 5 per cent solution of permanganate of potash (Condy's fluid) into the puncture provides immediate relief and prevents inflammation. Generally, fishes do not use their stings as organs of offence. They use them only on provocation, when attacked or trod upon.

The second category of venom relates to the flesh being poisonous and thus being dangerous to man. It is generally known that fishes, especially in a hot climate, putrefy and can thus cause food poisoning. Apart from these several poisonous fishes inhabit the Pacific, the Indian and Atlantic oceans. The best known are Barracudas, Tunas and Mackerels, all bottom feeders. The toxin occurring in some of these fishes is non-bacterial and is one of the most deadly poisons ever isolated. It is called 'Cigua tera'. Scientists are trying to detect its chemical nature and find an antidote. Their research leads them to believe that Dinoflagellata, microscopic one-celled animals which compose the plankton on which the fishes feed, are the source of the toxin.

The poison causes nausea, vomitting, diaorrhea, itching and numbness sometimes accompanied by fall in blood pressure and heart rate. Symptoms may appear in a few hours or after few days. American scientists are trying to devise and patent an analysis kit to detect the poison in fish catches. This will be a boon to people living in the numerous islands of the Pacific and who depend on fishes mainly for proteins. Some members of the Puffer fishes are believed to be poisonous, The 'oil fish' or 'purgative fish' (*Ruvettus pretiosus*) is a dangerous one, as its flesh has been reported to cause symptoms like numbness of tongue, hands and feet, pain in the chest and abdomen and general weakness.

CHAPTER VI

BREEDING AND PARENTAL CARE

A LARGE MAJORITY of fishes, like birds and mammals, do not show any external differences between the male and female sexes. Further, being aquatic, fishes do not lend themselves to direct observation. Therefore, a large number of myths and legends grew around the subject of reproduction among fishes. The famous angler, Izaak Walton, affirmed that they reproduced by spontaneous generation. Oppian suggested that the young ones arose from the mucus or slime of their parents. Aristotle believed that the female swallowed the seminal fluid of the male and the gametes came together inside her body somehow. More strange ideas prevailed in the case of eels, whose migratory habits were linked with breeding.

During the course of studies on animals, it soon became clear that in fishes the sexes are separate. The reproductive organs or gonads of fishes are of two kinds, the ovaries (hard roe) in the female and the testes (soft roe) in the male. They are usually elongate, paired organs, lying close to the kidneys. The ovaries are pinkish or yellowish in colour and granular in texture. In the breeding season, the ovaries get enlarged as the egg-cells grow bigger, when they become visible as tiny spherical bodies. The mature egg-cells pass to the exterior through the oviduct, opening either by a special aperture or by one which it shares with the kidney duct. In a large majority of bony fishes, there are no permanent oviducts. The ripe ovaries burst and the eggs drop into the main body cavity from where they pass out through temporary 'genital funnels' to the exterior. The testes are somewhat smaller in size and paler in colour with a smooth surface and occupy much the same position near the kidney as the ovaries do. A narrow duct leads from each testis to the genital opening near the anus.

The act of reproduction in animals is associated with courtship, sexual display and pairing of male and female, as is the case with birds and some mammals. In fishes, sexual differences and associated behaviour of courtship and pairing are rare. The majority of fishes, especially those which go about in large numbers (shoals or schools) breed at random, whereby the ovum and sperm meet in the surrounding water to form a zygote, This is an instance of external fertilization as contrasted with the internal fertilization of higher animals, where eggs are fertilized by sperms in the reproductive tract itself. Where fertilization is external and eggs and young ones are not tended by parents, the mortality rate is bound to be high. However, nature takes care of a reasonable degree of survival by providing infinitely large numbers of eggs. An ordinary fish like cod, salmon or plaice may lay from 250,000 to 500,000 eggs in a single spawning season.

Are there spawning seasons for fishes? At what age do they attain maturity? These and other questions do arise in the minds of people. With regard to the time and periodicity of spawning. it may be said that they vary from region to region, depending on climatic conditions. It has been observed in Europe that several food fishes breed in the first half of the year. The spawning season of the plaice (*Pleuronectes*) is from January to April; that of cod (*Gadus*) in the North Sea from February to May; that of the sole (*Solea*) from April to July.

In India, most of the carps and catfishes breed just before or during the rainy season. There are slight regional fluctuations, depending on the outbreak of the monsoon. Thus, in the eastern parts of India, carps, and catfishes lay their eggs in June, July and August, and in the northern regions of India, the season starts in July and goes on to August and September.

Hilsa breeds in Bengal during the south-west monsoon from June to August, while in Orissa it does so in the months of June and July. The chital, *Notopterus*, spawns from June to August.

Other fresh-water fishes like *Anabas*, *Clarias*, *Heteropneustes* and *Channa* (*Ophicephalus*) also breed during the monsoon.

Fishes attain sexual maturity at various ages. Some are ready to reproduce at the age of one, others when two or three years old. In eels, as already said, the females are ready to spawn at the age of 10 or 11, which is an exceptional feature in such lowly creatures as fishes.

As explained earlier, fishes in general are egg-laying (oviparous) in habits. But there are a few groups which bring forth their young ones alive (viviparous). Some of the sharks and rays and a few bony fishes afford interesting examples. In these fishes, sexual dimorphism is pronounced.

In the reproductive organs of sharks there are two uteri and each may harbour 7 or 8 or even more young ones during gestation. Fertilization takes place in the oviduct and the young ones grow inside the uterus, which has a special device to nourish them. The yolk sac of the fertilized egg, after the yolk is used up in the initial stages of embryonic development, gets attached to the inner uterine wall, while the embryos get suspended by the neck of the yolk sac. Thus an arrangement similar to that of a mammalian placenta is formed, whereby food from the yolk sac will eventually pass through the blood vessels. In rays, the inner wall of the uterus develops filament-like processes or villi (trophonemata), richly supplied with blood vessels and capable of secreting a creamy nutritive fluid into the uterine cavity which is either absorbed by the blood vessels of the yolk sac or directed through the gill-openings or mouth of the embryo.

Among bony fishes, viviparity is rather rare. However, among the toothed carps (*Cyprinodonts*), the surf-fishes (*Embiotide*) of the North Pacific, the Blennies (*Blennoidae*), viviparity has been observed. The eggs are fertilized while still in the ovisac and may undergo development in it. The embryos are nourished by the yolk sac or by special secretion of the wall of the ovisac.

One may imagine that these lowly creatures, which produce millions of eggs and throw them to the mercy of wind and water have no concern or care for the young ones. In general, they may not but there are a large number of interesting cases, where parents protect and take care of young ones.

The most primitive is the habit of nest-building. The nest may be a simple trough or a hollow cleaned out in the sandy

CARPS

Labeo rohita Ham.

Hindi—*Rohu*; Bengali—*Ruee;* Marathi—*Tambada masa;* Oriya—*Rohu;* Punjabi—*Rohu;* Assamese—*Rohitii*

This is the most famous carp found all over northern and central India up to the Godavari river. In the last few decades, attempts have been made to introduce it into peninsular India. They are now found in the Godavari and Krishna rivers.

Rohu has an elongated body, with a moderately rounded abdomen. Head prominent with blunt snout. Lips thick. Colour brownish grey to blackish above, scales with orange to reddish centre. Attains a length of 90 cm when full-grown.

Besides *Labeo rohita*, there are several other species abundant all over North India.

Cirrhina mrigal Ham.

Hindi—*Narain;* Bengali—*Mirgala;* Telugu—*Yerramosu;* Oriya—*Mirrgah;* Punjabi—*Mori*

This carp resembles *Rohu* in general shape but is somewhat more slender. It has a wider mouth and thinner lips. Body silvery, dark grey along the back, sometimes with coppery tinge. Pectoral, pelvic and anal fins orange in colour tipped with black. *Mrigal* attains a length of about 66 cm and a weight of 1.4 to 2.8 kg.

Catla catla Ham.

Bengali—*Katla;* Telugu—*Botchee;* Tamil—*Theppu meenu;* Malayalam—*Karakatla;* Oriya—*Barkur;* Kutch & Bombay—*Tambra;* Punjabi—*Theila;* U.P.—*Catla;* Assam—*Baudhekera*

Catla is the largest Indian carp, attaining a maximum length of about a metre. Found throughout India, although rather scarce south of the Krishna river. Body broad, deep and stout. Dorsal profile more convex. Head large with prominent lips. Colour blackish grey above and silvery on the sides. Scales with pink or coppery centre on the dorsal side and whitish below.

Cyprinus carpio Linn. (COMMON EUROPEAN CARP)

Although not a native of India, it has been introduced into the lakes of the Nilgiri mountain ranges from China and South-East Asia. It was first introduced into Ceylon and later into South India, where it has been successfully acclimatized; it breeds throughout the year. Three varieties are found in the Nilgiris: (i) *Cyprinus carpio specularis* (mirror carp) (ii) *C.c. nudus* (leather carp) and *C.c. communis* (scale carp). They grow to about 76 cm and weigh 6.5 kg.

Besides the three major carps mentioned above, there are several smaller types found in India. One of the best known of minor carps is *Puntius* or *Barbus*. Several species are found throughout the country. *Puntius amphibius*, *P. carnaticus*, *P. chola*, *P. curmuca*, *P. dubius*, *P. jerdoni*, *P. micropogon*, *P. sarana* and *P. sophore* are well-known and are commercially important as food fishes, although their flesh is coarser and less tasty than that of the major carps.

One of the famous carps in Northern India is the *Mahaseer* which belongs to the genus *Tor*, but was formerly believed to be *Barbus*.

Tor tor Ham. (Syn: *Barbus tor*, Day)

Hindi—*Naharm;* Bengali—*Tor*, *Mahaseer*, *Mahasol*, *Putitor;* Marathi—*Khadchi*, *Mesta;* Kannada—*Peruval;* Malayalam—*Meruval.*

Mahaseers are found in hill streams and the upper reaches of rivers in the northern latitudes. Their body is adapted to counteract torrents and fast-flowing streams. The snout is pointed, the body narrow and the tail long. Like salmon they can leap against currents and ascend waters. Scales are cycloid and hexagonal in shape and can grow to a very large size. In fact, the *Mahaseer*'s scale is rated as the largest among the modern teleosts. The fish is deep green or olive on the head and back, golden on the upper side of the body, toning to white below. Fins are yellow with a red margin.

The *Mahaseer* grows to a large size about a metre long and ranks very high as food fish. They are also considered a good game fish by anglers. They are now cultured in dams in Punjab, like the Bhakra-Nangal.

CATFISHES OR SILUROID FISHES

Catfishes are the second major group of fresh-water fishes. There are many families, genera and species, ranging from large specimens living in rivers and lakes to very small ones in streams and creeks on plains or mountains. Most of them are considered good for eating. They are scaleless. Being provided only with a single column of backbones and none in the muscles, unlike carps, they are preferred by some people, although certain communities like the Jews and Mohammedans have a prejudice against them.

In the following pages, a few chosen examples of the important catfishes will be described.

Wallago attu (Sch.)

Hindi—*Boalee;* Bengali—*Boyali;* Marathi—*Shivada;* Telugu—*Valuga;* Tamil—*Valai;* Kannada—*Bahle;* Malayalam—*Attuvalai;* Punjabi—*Mully*

The most widely distributed of Silurids, it is found in rivers and lakes throughout India. It is often referred to as a 'fresh-water shark' on account of its large mouth, toothed jaws and predatory habits. The body is laterally compressed with a straight back. Head is very large, trunk small and tail disproportionately long and tapering. It grows to nearly a metre or two long, although the market size in around 60-90 cm only. It predates on other fishes, particularly young carps. Being a good game fish, it is popular with anglers.

Mystus seenghala (Sykes) or *Macrones seenghala* of Day

Hindi—*Ari;* Bengali—*Air;* Marathi—*Singala;* of Telugu—*Multijellah;* Tamil—*Cumbookelutti;* Kannada—*Shede;* Malayalam—*Karatta;* Punjabi—*Shingaree*

This fish belongs to the Bagrid catfishes in which the adipose dorsal fin is well-developed. It is widely distributed in India, being found in the Jamuna, the Ganges and the Deccan rivers as well as the Assam rivers. Body is brownish above with silvery sides. One of the distinguishing features is the circular black spot on the adipose fin. The snout is distinctly long. Attains a length of about 120 cm. It is predatory in habits and attacks small carps, other small teleosts and prawns.

Besides *M. seenghala*, there are other related species. *M. vittatus* (Bloch) occurs throughout India but is more common in Tamil Nadu. *Mystus aor* (Ham.) is widely distributed in India and grows to a large size, about a metre long. *M. cavasius* (Ham.) is a smaller kind, about half-a-metre long and is common in fresh waters all over India. It is esteemed as food.

Rita rita (Ham.) or *Rita buchanani*, Day

A small Bagrid catfish found in fresh waters throughout India, except in Tamil Nadu and Karnataka States. Colour brownish, olive green and lighter below. Average size about 45 cm but maximum may be 120-125 cm long.

Ompok bimaculatus Bloch or *Callichrous bimaculatus* of Day

Hindi—*Puffta;* Telugu—*Duka-damu;* Tamil—*Chotawahla;* Kannada—*Godla;* Malayalam—*Mungee-wahlah;* Punjabi—*Pufta*

This fish is a typical member of the Silurid family popularly called sheat fishes, in which the dorsal fin is short or absent, the adipose absent, the anal moderately long and barbels two pairs. Body is laterally compressed, silvery or greyish brown, shot with purple. A black spot above the spectoral fin. Anal with black edge. Caudal fin deeply forked with sharp lobes. The Bengal specimens measure about 15 cm long. Large specimens up to 50 cm are caught in Malabar. It is an excellent food fish. Found throughout India, particularly in larger rivers, but is more common in Tamil Nadu and Malabar.

Pangasius pangasius (Ham.) or *P. buchanani*, Day

Hindi — *Pariasi;* Bengali — *Pungas;* Telugu — *Choluvajella;* Tamil—*Kovailoolakeluthai*

A member of the Schilbeid family of catfishes with short or moderately long anal fin, quite separate from the forked caudal. Adipose dorsal fin present. First dorsal fin short, with strong spine, provided with poison glands. Found both

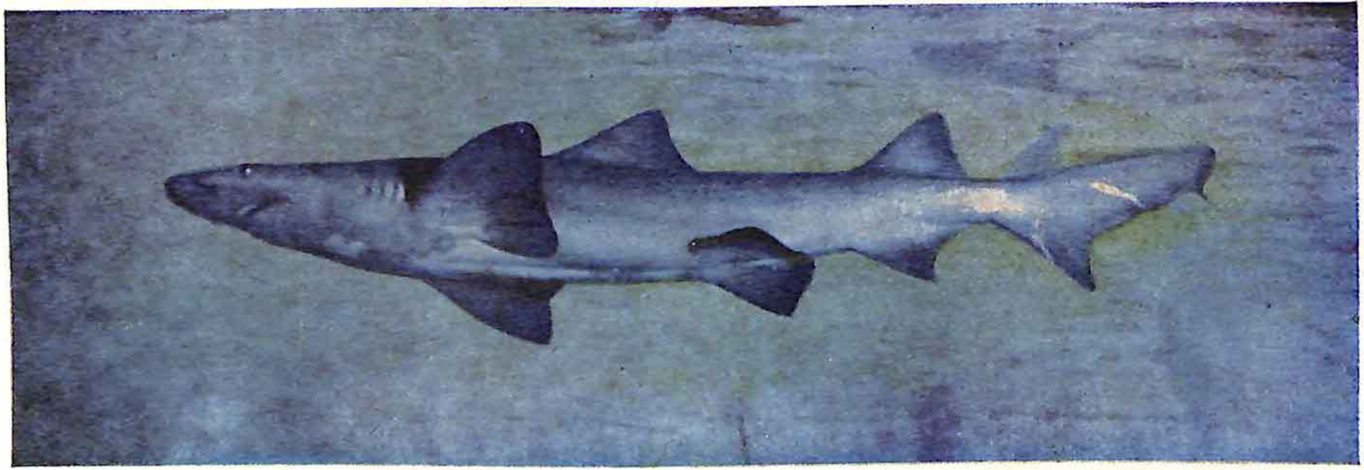


Plate 1 Indian Blue Shark

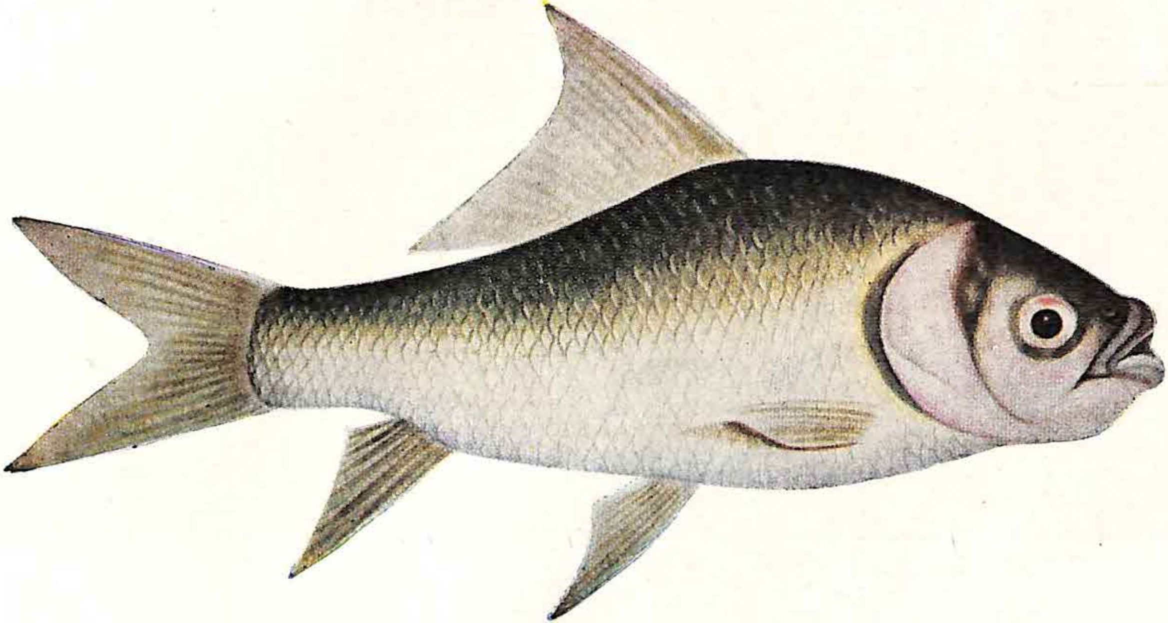


Plate 2 *Catla catla*

in fresh waters and estuaries, particularly those of the Bay of Bengal. Body silvery, dark along back and glossed purple on sides. Snout and cheeks golden. Carnivorous and predates on young fishes, mostly carps and molluscs.

Eutropiichthyes vacha (Ham.)

Hindi—*Bachwa;* Bengali—*Vacha;* Oriya—*Butchwa;* Punjabi—*Jalli*

A moderate-sized Schilbeid catfish, growing up to 30 cm. Common in the big rivers of North India. Body silvery, dark on the back. Considered tasty food fish.

Clarias batrachus (Linn.) or *Clarias magur* of Day

Hindi—*Mangri;* Bengali—*Mah-gur;* Telugu—*Marpoo;* Tamil—*Masarai;* Malayalam—*Yerivahlay;* Punjabi—*Kug-ga*

In general, Clarid family is restricted to Africa, southern and western regions of Asia, including India. Only one species, *Clarias batrachus*, occur in fresh waters and brackish waters throughout India. Body elongated, head depressed with top and sides covered with osseous plates. In the gill chamber are the tree-like organs, specially designed to take in oxygen from the air. Barbels four pairs, pectoral fins with spines. Dorsal without spine. No adipose fin. Caudal fin rounded. Colour uniform brown or greyish black, length about 45 cm. Esteemed as food. It is used in laboratories for experimental purposes, being a hard variety.

Heteropneustes fossilis (Bloch) or *Saccobranchus fossilis* of Day

Hindi and Bengali — *Singhi;* Marathi — *Bitchuka-machi*; Telugu—*Mapujella;* Malayalam—*Kahrimeen;* Punjabi—*Noorie*

This fish is the only member of the *Heteropneustid* family of catfishes. Head flattened, body elongated and laterally-compressed. Dorsal fin short, without spine. Anal fin elongated. Pectorals strong with poison spine. Barbels long, four pairs. The fish is noted for its accessory air-breathing organs, which are a pair of lung-like sacs, arising from the gill chamber and embedded in the body muscles. Found in estuaries and fresh waters. Length about 30 cm. Popular as food.

Although the majority of catfishes are fresh water, a few families have established themselves in the sea. One of the commercially important groups is the family *Tachysuridae* (Ariidae).

Tachysurus dussumieri (Val.) or *Arius dussumieri* of Day

Marathi—*Shingala;* Telugu—*Jedi-jella;* Tamil—*Mandai valsi;* Kannada—*Mongam-shede;* Malayalam—*Valiaetta*

More abundant on the Malabar coast. Body stout, with broad snout, bluish along back, lighter below. Commercially important group. Relished as food, both in fresh and salted conditions. Air-bladder of marine catfishes is a valuable source of isinglass.

The other important species are *T. jella*, *T. maculatus*, *T. sona* and *T. thalassinus*.

These catfishes rank high in the marine fishery of India with an annual tonnage of 20,000 to 25,000.

Murrels or *Snake-heads* (Order OPHIOCEPHALIFORMES or CHANNIFORMES)

These fishes belong to the order Ophiocephaliformes or Channiformes. They are abundant in India, Burma, Sri Lanka, Taiwan, Malay peninsula, Thailand (Siam), China, Taiwan and Islands of the East Indian Archipelago. A few species also occur in Africa.

There are about eight well-known species of *Ophiocephalus* or *Channa* in India. They are popularly referred to as 'snake-heads' from the shape and appearance of the head, which resembles that of a snake. Body elongated, anteriorly cylindrical, posteriorly compressed. Dorsal and anal fins single and long. They are also noted for their air-breathing habit. On the roof of its pharynx, the fish has a pair of cavities which have folded linings, richly supplied with blood vessels for taking in air. These organs enable these fishes to survive out of water for a few hours or migrate from one pool to another. They are therefore called 'live fishes' or 'Jiol Machi'. They build crude nests to rear their young ones. Three most important species are described below.

Channa marulius, (Ham.) or *Ophiocephalus marulius* of Day

Hindi — *Pumuri;* Bengali — *Sal;* Telugu — *Pool-a-malle;* Tamil—*Aviri;* Kannada—*Madinji;* Malayalam—*Bral;* Punjabi—*Kubrah* or *Sawl*

This is about the largest of murrels in India, the average size being about 45 cm but may attain over a metre. Found in all large rivers, as they prefer deep clean stretches of water with a sandy or rocky bottom, unlike several of its related species. It is cultured in tanks, ponds and irrigation canals in certain parts of India. It is valued as food.

Channa punctatus Bloch or *Ophiocephalus punctatus* of Day

Hindi—*Phool-dhok;* Bengali—*Taki;* Telugu—*Mitta;* Tamil—*Korava;* Malayalam—*Kayichil;* Punjabi—*Dulloonga*

A widely distributed species smaller in size. Prefers stagnant waters. Variable in colour, usually greenish brown above, yellow below; but may take a purplish to black hue. Average length 11 cm in the hills to 31 cm in the plains. Prolific breeder. Useful as food.

Channa striatus Bloch or *Ophiocephalus striatus* of Day

Hindi—*Morrul;* Bengali—*Shol;* Marathi—*Sohr;* Telugu—*Korrameen;* Tamil—*Virahl;* Malayalam—*Kannan;* Punjabi—*Sowl*

Distributed widely from the Indo-Gangetic plain to peninsular India. These fishes are medium-sized. Body dark brown or black above, yellowish or orange below. Prefer stagnant, muddy waters. Feed on worms, insects, tadpoles and frogs. Widely cultivated in tanks of Tamil Nadu. Like other murrels, this species is also esteemed as food.

Murrels being typical 'live fishes' and, having soft flesh devoid of fat, are considered to have medicinal value and provide nutritious food, particularly to the sick.

Family: *Notopteridae* (FEATHERBACKS OR CHITAL)

Featherbacks belonging to the family Notopteridae are important resources for fresh water fishery and are therefore included here. They belong to the order Isospondyli or Clupeiformes, an essentially marine order. Some families and occasionally isolated genera or species have migrated to the fresh waters or evolved there in olden times. *Hilsa ilisha* is an example of the first kind and *Gadusia chapra* that of the second.

Featherbacks have a peculiar shape, with a small head, a flattened bony and an upturned tail, suggestive of a knife. Body is covered with minute scales. Dorsal fin is small and sticks out like a feather and hence the popular name 'featherback'. Paired fins—both pectoral and pelvic – are very small. The anal fin is extensive and is joined with a caudal, giving the fish its characteristic shape. Two species occur in India.

Notopterus chitala (Ham.)

Bengali—*Chital;* Tamil—*Ambutan-walah;* Oriya—*Pulli;* Bihari—*Mohi;* Punjabi—*Pari*

This species has a conspicuous humped dorsal profile. Body coppery brown or greyish along the back with 15 or 16 silvery transverse bars. Average length 25 cm but may reach a metre. Commercially important as food fish.

Notopterus notopterus Pallas or *N. Kapirat* Pallas Day

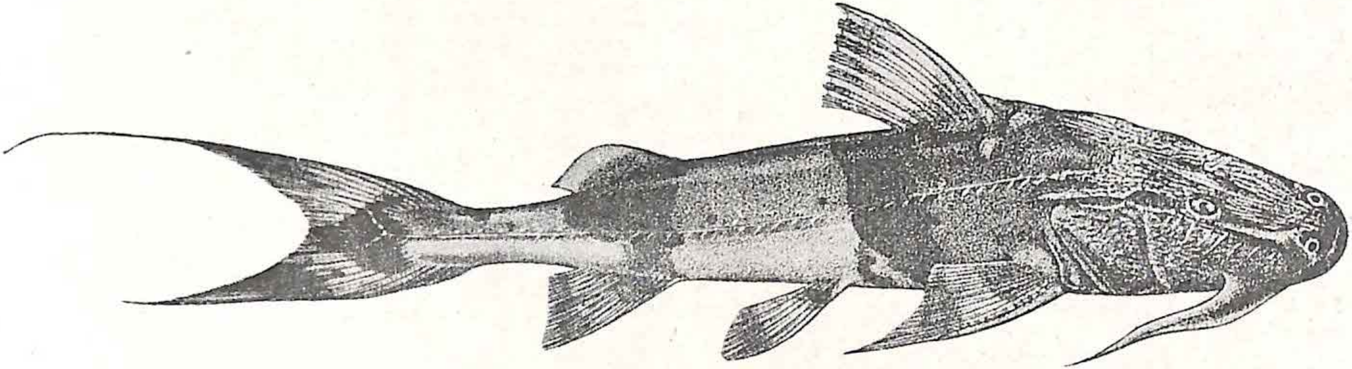
Hindi—*Pholi;* Bengali—*Pholui;* Telugu—*Ulakathatta;* Tamil —*Ambattan-kathi;* Punjabi—*Moh*

Occurs in fresh or brackish waters of India. Body silvery white with fine grey spots along the back. Average market size 25–45 cm but maximum size may be about 60 cm. It is cultivated in large lakes and reservoirs of Tamil Nadu. It is in demand as food fish.

Grey Mullets (Mugils): Family Mugilidae

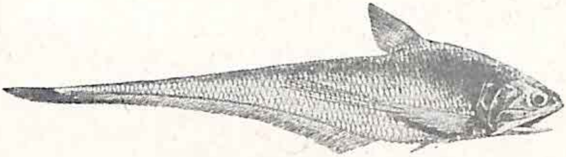
These fishes belong to the family Mugilidae and to the order Perciformes and are different from the so-called white mullets or *Chanos* of the order Clupeiformes. Grey mullets are fishes in which both body and head are covered with large cycloid or ctenoid scales. Of the 26 species recorded in India, the majority are estuarine and marine in habits, but a few migrate to rivers. Some species are cultivated in large tanks and ponds. The three species important in fresh water fishery are described.

PLATE—V

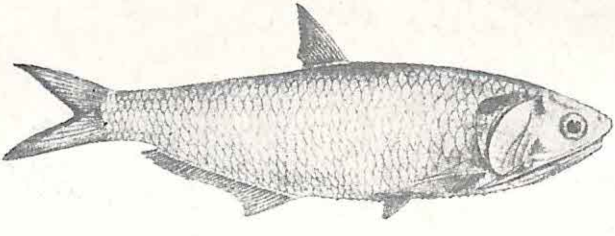


Catfish—GOONCH *(Bagarius bagarius)*

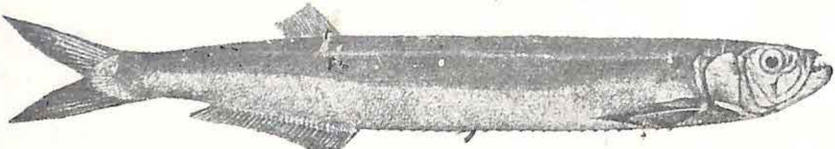
PLATE—VIII



Anchovy (*Coilia dussumieri*)



Anchovy (*Thrissocles mystax*)



Silverbar—DORAB (*Chirocentrus dorab*)

Mugil cephalus Linn. or *Mugil oeur* Day

Bengali—*Ain;* Telugu—*Kathiparega;* Tamil—*Madavai;* Kannada—*Mala;* Malayalam—*Tirutha;* Bombay—*Bol*

This fish is the largest of grey mullets and most widely distributed along the coastal waters, migrating into estuaries and rivers. It attains a length of about 90 cm. It is cultivated in tanks in Tamil Nadu and Kerala States.

Mugil macrolepis Smith or *Mugil troschelli* Day

This species of mullet occurs along the Bombay coast and as far south as the Gulf of Mannar, along the peninsula. Being adaptable to brackish and fresh water conditions, it is extensively cultivated in lakes and ponds in Tamil Nadu State.

Mugil parsia Ham. or *M. dussumieri* Day

Medium-sized mullets, average length about 12-15 cm attaining 25 cm at its maximum. Colour greenish above with 3-6 stripes along the body. It is a typical estuarine species found all along the coast of India, but is more common in the Bay of Bengal area.

Family *Sphyraenidae* (BARRACUDAS)

Related to Mugils but marine, Barracudas, otherwise known as 'Sea pikes' are large sized, slender, pelagic marine fishes occurring in large quantities along the Indian sea coast. Their distribution is worldwide. There are four well known species in the Indo-Pacific ocean. They are *Sphyraena barracuda* (Walbaum), *S. jella* (Cuvier), *S. fosteri* (Cuvier) and *S. obtusata* (Cuvier). The first two species measure about 1.5 metres, while the last two species measure 40-60 cm. in length. The common size caught are only 20-30 cm. The gears used are hooks and lines, gill nets, drift nets and boats employed are trawlers.

Barracudas have powerful jaws armed with flattened sharp-edged dagger like teeth. They are predatory in habits and feed on other fishes. The large-sized species, ferocious and fearless, occurring in the West Indies are dreaded by fishermen more than sharks, and are reputed to attack human beings.

From the Indian seas (1969-80), maximum landing af 4812 tonnes was recorded in 1974 and 2265 tonnes in 1979, of which Tamil Nadu contributed a good portion. The large varieties are in good demand due to their delicate flesh and they are marketed in fresh condition.

MARINE

Order ISOSPONDYLI or CLUPEIFORMES

Includes sardines, herrings, anchovies, salmons and their allies. They are mostly marine, although a few are estuarine fishes and fresh water in habits. This is a very extensive order and embraces a large number of families and their genera. It is proposed to consider here only those which are important as sources of food, oil and other by-products.

The family *Clupeidae* includes sardines and herrings which are the most important commercially. They move about in large shoals or schools. They are comparatively small fishes about 15 cm long, with a narrow elongated and laterally compressed body, with a row of thorn-like scales along the ventral edge of the abdomen. Mouth large, jaws equal; scales cycloid and fall off easily. The most important members fall under the genera *Sardinella*, *Dussumieria Hilsa and Ilisha* or *Pellona*.

There are about seven species of *Sardinella*.

Sardinella longiceps (or *Clupea longiceps*) is the best known, populary called oil sardine or Malabar sardine.

Marathi—*Haird;* Telugu—*Noona-Kavallu;* Tamil—*Paichalai;* Malayalam—*Nallamathi*

Oil sardine is common from Sind to the Andhra coast, but is particularly abundant in the Malabar and Konkan areas. The fish has an elongated body with a large head. Colour is bluish brown with a golden shimmer along the back, while the abdomen is silvery, shot with purple. A large, greenish golden spot on the opercle is distinctive. It is an excellent food fish, whether fresh or canned. It yields rich body oil.

Other species are *Sardinella fimbriata*, *S. albella*, *S. gibbosa*, *S. melanura*, *S. sindensia* and *S. sirm*. They are also edible and are sources of oil and fish-meal or manure.

The rainbow sardine or common sprat belongs to the genus *Dussumieria*. There are two well-known species.

Dussumieria acuta (Val)

Tamil—*Poondusuringa;* Malayalam—*Challay*

Found along the east coast from Chilka Lake to Bombay.

The fish resembles the oil sardine, but the ventral abdominal scutes are lacking and the body is more rounded. Colour along back bluish green which is marked off from the silvery lower half by a golden lateral band, while the head is emerald green. This melody of colours probably gave rise to its popular name rainbow sardine.

Dussumieria hasselti, (Blkr) is the second species and is found from the Andhra coast to Kanara.

Both species contribute to sardine fishery.

Hilsa is famous throughout India on account of its being a popular food fish, particularly in Bengal. It is the largest among sardines. There are three species in India.

Hilsa ilisha (Ham.) (or *Clupea ilisha* of Day)

Hindi—*Hilsa;* Bengali—*Ilisha;* Telugu—*Palasah;* Marathi—*Pala;* Tamil—*Oolum;* Kannada—*Paliya;* Malayalam—*Paluva;* Bombay—*Chaksi; Palva*

Body laterally compressed, oblong with dorsal and ventral profiles equally convex. They are found from the Persian Gulf along the entire coast of India to Burma. They ascend rivers beyond tidal limits and have been recorded as far off as Allahabad on the Ganges. Colour silvery, shot with gold and purple, greenish above; average size 38-46 cm; maximum size about 60 cm, weight 2.50 kg.

Hilsa kanagurta Day or *Clupea kanagurta* Day

Telugu—*Keelee*; Malayalam—*Ayalay*

Colour bluish green on back, sides golden and dotted with purple. A black spot on shoulder. Young ones may have 3-8 spots near anal fin. Found both in the Bay of Bengal and the Arabian Sea but caught more on the Coromandel coast.

Hilsa toli Val or *Clupea toli* Day

Bombay—*Bhing;* Bengali—*Chandana-Hilsa*

More common on the Bombay coast. May be distinguished from *Hilsa ilisha* by its longer caudal fin, smaller head and large scales. Colour silvery, with a tinge of yellow and purple. Blackish on the dorsal side. Length 60-90 cm. Important fishery of Cambay and Bombay coasts.

Pellona ditchella Val or *Pellona hoevenii* Day

Abundant on the Andhra and Coromandel coasts.

Family *Engraulidae* (ANCHOVIES)

Anchovies constitute the second big family and includes mostly translucent, pelagic and shoaling clupeoids in which the maxillary portion of the upper jaw is prolonged backwards beyond the eye; mouth wide, oblique. Lateral line absent. Belly with numerous keeled abdominal scutes.

Anchovies fall into four important genera: *Setipinna, Coilia, Thrissocles* and *Anchoviella.*

Setipinna breviceps (CANTOR) or *Engraulis breviceps* of Day

Found in the seas and estuaries of the Bay of Bengal extending to Malaysia and Indonesia. Upper profile markedly convex between snout and dorsal fin. Lower profile nearly straight. Mouth very oblique with lower jaw projecting. Body silvery greenish yellow; dorsal, caudal and posterior half of anal fins black-edged.

Setipinna phasa (Ham) or *Engraulis telara* Day

Hindi—*Bindi;* Bengali—*Phansa*

Populary called the Gangetic anchovy, found on the coasts of Bengal and Orissa and entering estuaries and rivers upto the tidal limits. Body greenish along back, sides silvery and golden along the abdomen. Length 40 cm or less.

Setipinna taty (Val) or *Engraulis taty* of Day

Body oblong, strongly compressed, found in the seas and estuaries of Bombay and Orissa. Upper part of body dark green or greenish yellow, rest silvery. Length 15 cm.

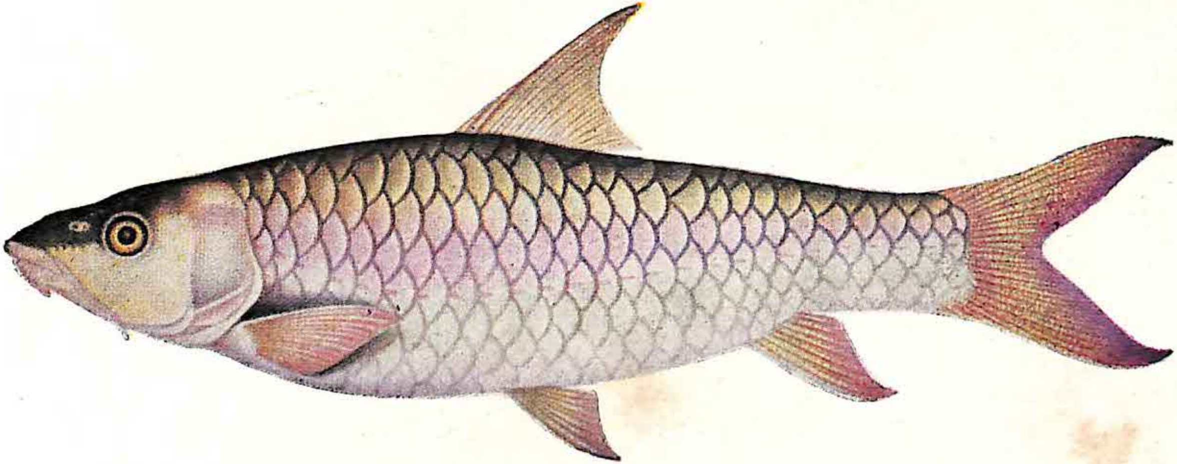
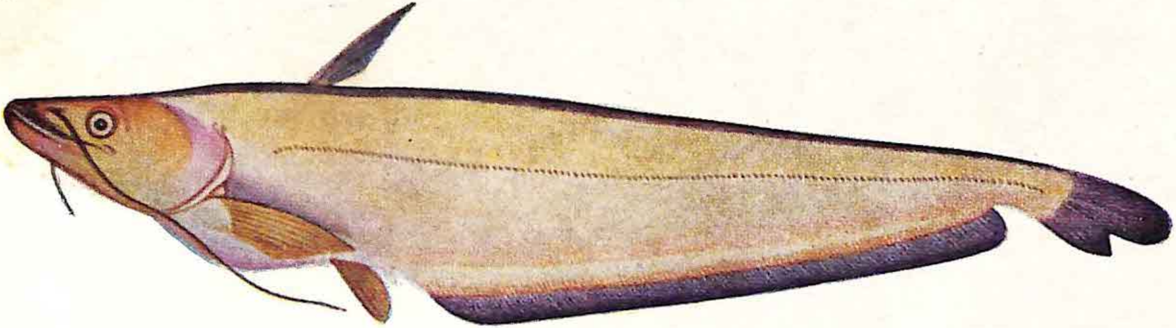


Plate 3 Mahaseer *(Tor tor)*



Ptate 4 Freshwater Catfish—MULLY *(Wallago attu)*

Anchovies of the genus *Coilia* can be distinguished easily by its peculiar body shape. *Coilia* has a long, tapering caudal region and the anal fin fuses with the caudal fin. Pectoral fin bears a few free filaments.

Coilia dussumieri (Val)

Oriya—*Oorialli*; Bombay—*Mandeli*

Best known species, common in the estuaries of Orissa and Bombay. Colour golden with 2 or 3 rows of bright and glossy spots along the lower half of body. Free pectoral filaments 5-6 reaching to the middle of body.

Two other species which occur commonly are *Coilia borneensis* off the Coromandel coast and *Coilia ramcarat* off Bengal.

Genus *Thrissocles* (formerly included under *Engraulis*) comprises typical anchovies and is represented in India by eight wellknown species.

Thrissocles boelema (Fosrk.) Body silvery, bluish above, head golden with a dark patch on the shoulder. Abundant in the Andamans.

Thrissocles dussumieri (Val.) A common anchovy off the Tamil Nadu and Malabar coasts.

Thrissocles hamiltoni (Gray)

Telugu—*Poorowah;* Malayalam—*Charlay*

Has a wide distribution in the seas as well as the estuaries of India. Body silvery; back dark; scapular region with black lines; maxilla extends to pectoral, dorsal and caudal fins with black edges. Length 15 cm. Used extensively as food on Bombay coast.

Thrissocles kammelensis (Blkr.)

More common in the Bay of Bengal than in other parts. Body golden, dark above, usually with a black blotch over the shoulder.

Thrissocles malabaricus (Bloch)

Telugu—*Poorawah;* Tamil—*Poor-relan;* Malayalam—*Chellamanangoo*

Distributed throughout the Indian seas. Body silvery, shot with golden and purple. A black patch of venules on shoulder. Length about 17 cm.

Thrissocles mystax (Sch.)

Telugu—*Poracalu;* Tamil—*Poruva;* Malayalam—*Nedumanangu*

Body compressed and thin. Found in seas and estuaries. Length about 15-18 cm.

Thrissocles purava (Ham.)

Marathi—*Katil;* Telugu—*Peddah-poorawah;* Tamil—*Nathal;* Malayalam—*Kavachella*

A widely distributed species along the east and west coasts in seas and estuaries. Body laterally compressed, silvery, steel blue along back, head with golden tinge. Length about 30 cm. Breeds in estuaries and tidal reaches of rivers. Esteemed as food.

Thrissocles setirostris, (Brouss)

Telugu—*Yekapoorwah;* Malayalam—*Chirumanangoo*

Found in the seas of India from the Bay of Bengal to Kerala. Body compressed and long. Silvery with greenish back. Maxilla long and reaching beyond ventral fin.

The fourth group of anchovies constitutes the genus *Anchoviella*, represented in India by two species.

Anchoviella commersonii (Lacep.) or *Engraulis commersonianus* of Day. Malayalam—*Netholi*. Found in the Bay of Bengal and the Arabian Sea. Abdominal scutes 6-7.

Anchioviella indica (v. Hass) syn. *Engraulis indicus* of Day

Telugu—*Nattoo;* Tamil—*Nettelle;* Malayalam—*Co-Netholi*

Found along the coasts of India, more abundant in Chilka Lake. Abdominal scutes 4-5.

Dorab fish of Bombay coast is a singular member of the clupeoids and belongs to the family Chirocentridae. It is referred to as a wolf-herring on account of its carnivorous and predatory habits. There is only one genus and one species.

Chirocentrus dorab. (Forsk)

Bengali—*Khanda;* Marathi—*Karli;* Telugu— *Mullu valai;* Tamil—*Valai;* Kannada—*Karli;* Malayalam—*Mulluvala*

Body compressed and elongated. Mouth large; lower jaw protruding and set with sharp, pointed teeth. Average length 1.2 metre but may attain 3.7 metres. Found in the seas around India, extending to China. Popular name silverbar fish but known in Bombay as *Dorab.*

Chanos chanos (Forsk) or *Chanos salmoneus* Day

Telugu—*Pallabontha;* Tamil—*Palai-meen;* Kannada—*Hoomeenu;* Malayalam—*Poomeen*

Body compressed; beautifully shaped, scales small, mouth small and toothless. Silvery green along back. More common on the Malabar coast. Breeds in estuaries. Highly esteemed as food and is of considerable importance in fish culture in embanked brackish water.

The milk fish or white mullet is a member of the family Chanidae, represented in India by a single genus and a single species.

It is proposed to add a paragraph on trouts in this section. Trouts or salmons are famous game fishes of the cold, mountain streams throughout the world. They belong to the clupeiod fishes. There are no indigenous or native trouts in India. Trouts have been introduced from abroad into the Himalayan mountain and Western Ghat streams where they have flourished for several years and contribute to trout fishery.

Salmo gairdnerii Richardson

This is the popular 'Steel Head', a native of California, U.S.A. It was introduced into the mountain streams of Kashmir and the Nilgiris and can thrive at a height of 1,800 metres and at a temperature of 3.3°C in winter and 15-21°C in summer. It reaches a maximum length of about 70 cm and weight 5.5 kg. The other species is the Loch Leven trout of Scotland. This flourishes in the Nilgiris.

Order PERCIFORMES: PERCHES AND THEIR ALLIES

Perches and perch-like fishes are a large assemblage of fishes falling under different families. They are mainly marine, although a few are inhabitants of estuaries and fresh waters. The majority of them are excellent food fishes and contribute a large percentage to our marine fisheries.

The order embraces a large number of families. The important ones are described below.

Family *Centropomidae* (SEA PERCHES)

Fishes with exposed maxillary bone. Scales ctenoid. Pelvic fins with axillary scale. Anal with three spines, dorsal continuous or interrupted.

Lates calcarifers (Bloch)

Bengali—*Bhetki;* Marathi—*Fitadar;* Telugu—*Pandu-chapa;* Tamil—*Painnee-meen;* Kannada—*Koliji;* Malayalam—*Chempalli* or *Narimeen*

Found in the seas from India to China, especially in the estuaries of large rivers on the eastern coast, ascending beyond tidal reach. Colour grey, dark green along back and silvery below. Average length 45-60 cm but may attain up to 150 cm. This species can be cultivated in tanks. It is a good game fish and is highly esteemed as food.

Family: *Epinephelidae* (ROCK PERCHES)

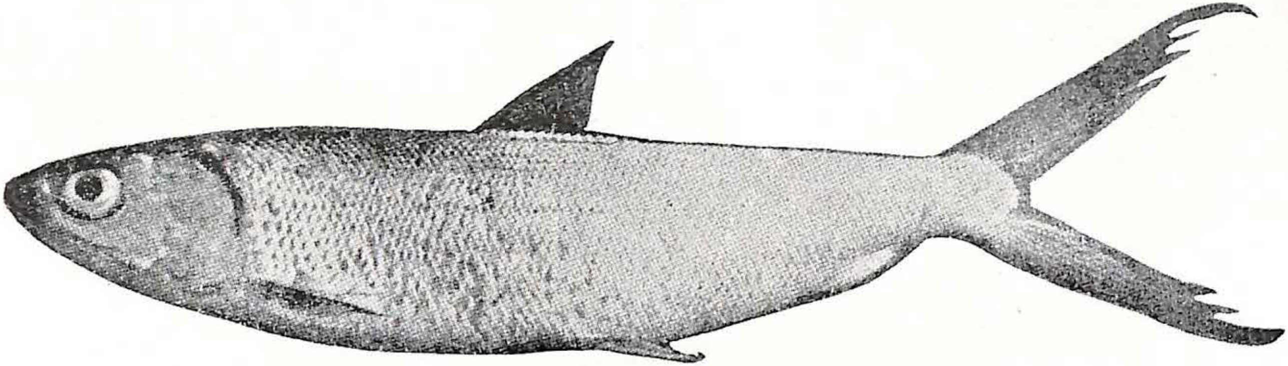
Body brilliantly coloured. Found all along the coast line. Some are big-sized fishes and are good for eating. *Epinephelus boenack* Bloch (*Serranus boenack* of Day) is the best known.

Family: *Sillaginidae* (SAND WHITINGS OF LADY'S FINGERS)

Their popular name is attributed to their burrowing habits and their transparent white colour. Elongated white fishes with round body, tapering caudally; scales small. Pointed snout with a small mouth. There are two well-known species.

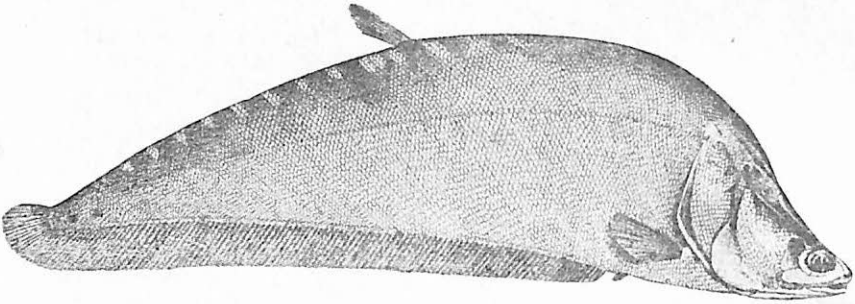
Sillago sihama, (Forskal)

Marathi—*Murdi;* Telugu—*Shorangi;* Tamil—*Kelakkan;* Kannada—*Kane;* Malayalam—*Poozhan*

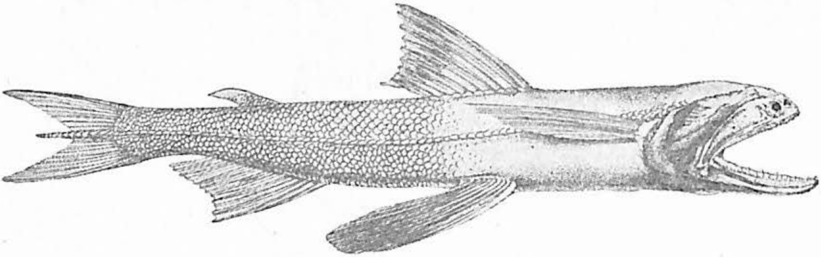


Milk Fish *(Chonos chanos)*

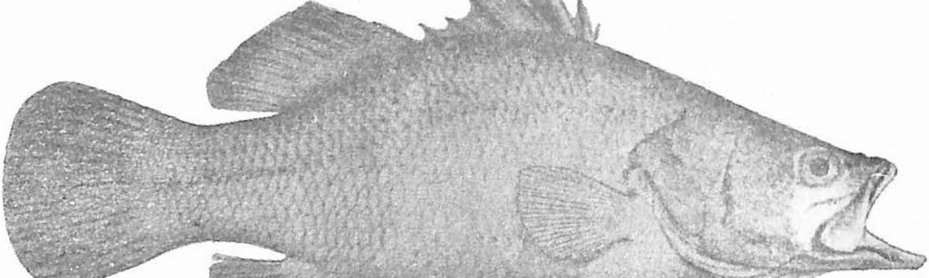
PLATE—X



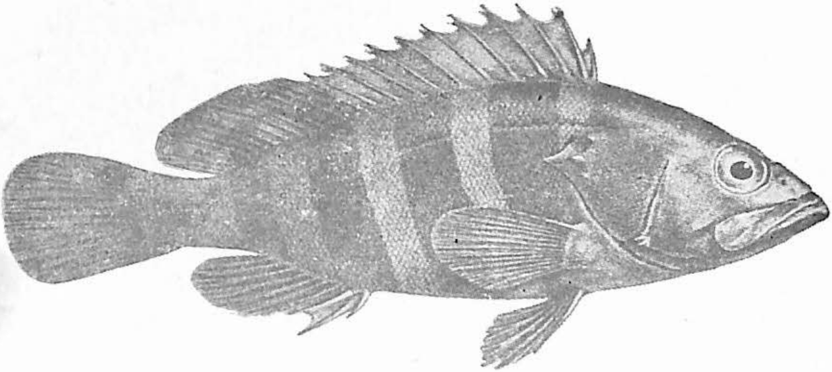
Chital *(Notopterus chitala)*



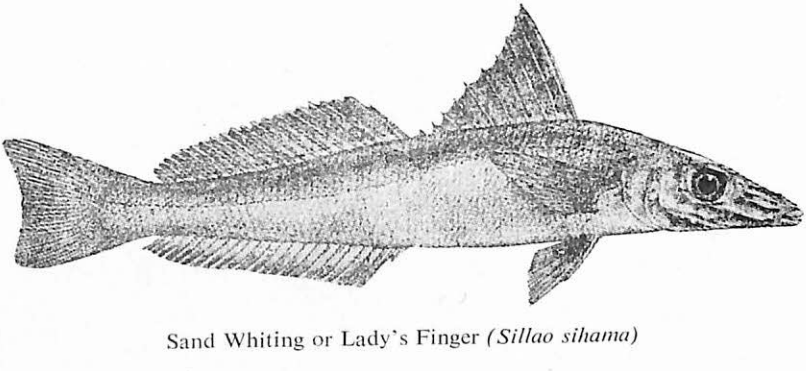
Bombay Duck *(Harpodon nehereus)*



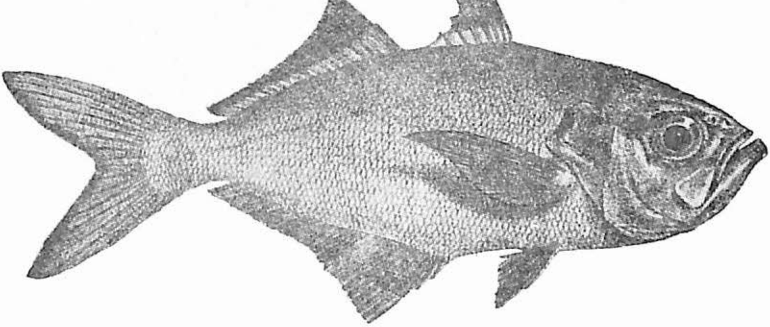
Sea Perch--BHEKTI *(Lates calcrifer)*



Rock Perch *(Epinephelus diacanthus)*

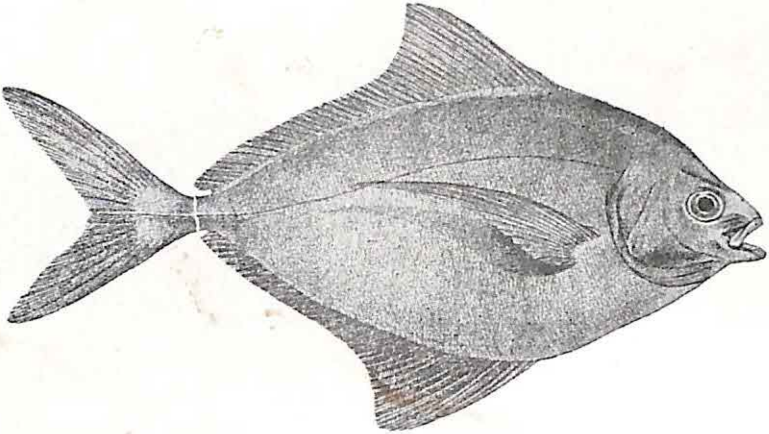


Sand Whiting or Lady's Finger *(Sillao sihama)*

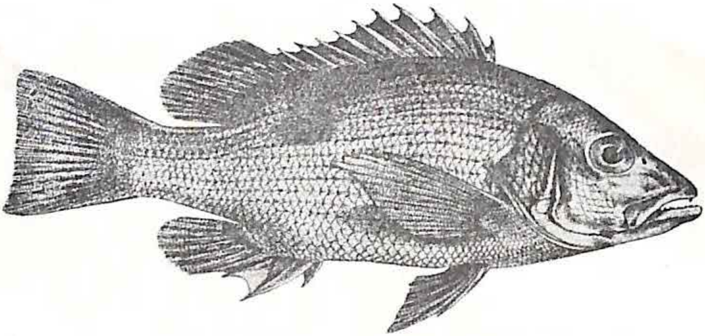


White Fish *(Laetarius)*

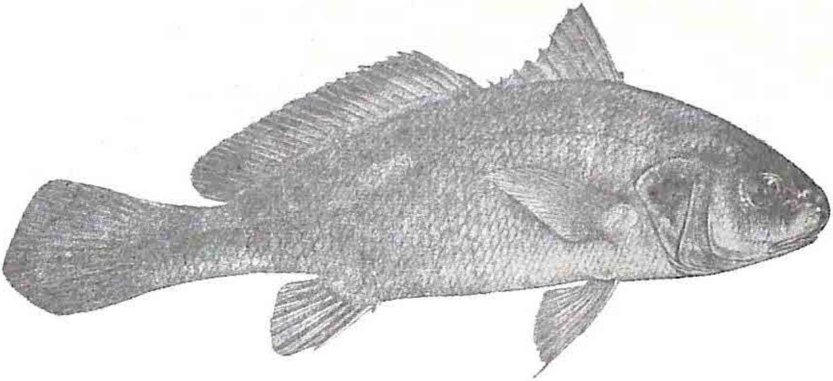
PLATE—XII



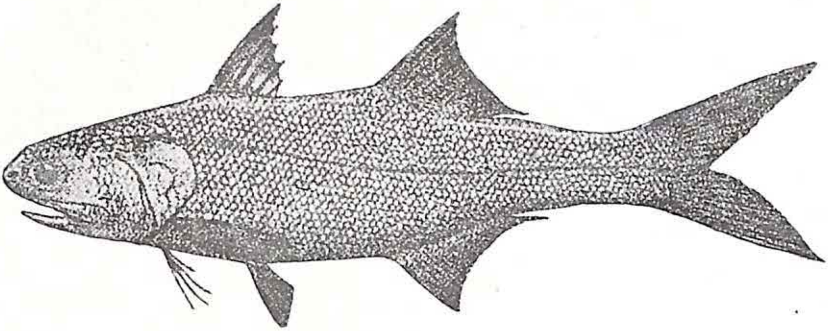
Black Pomfret *(Formio niger)*



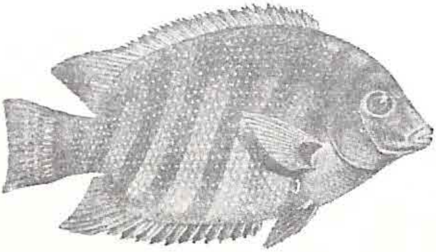
Moses Perch *(Lutianus johnii)*



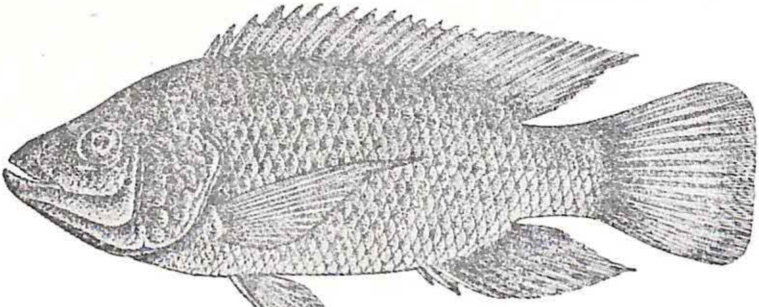
Jew Fish *(Johnius dussumieri)*



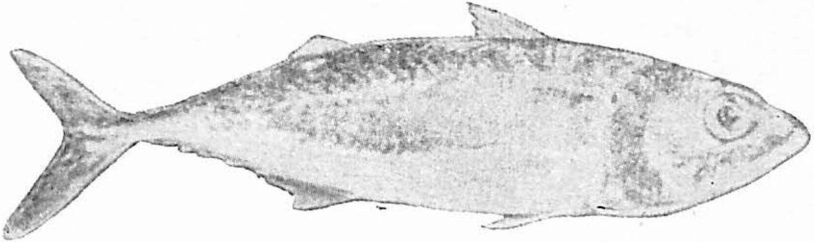
Indian Salmon *(Eleutheronema tetradactylus)*



Pearl Spot *(Etroplus suratensis)*

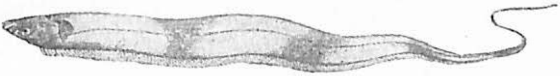


Tilapia (*Tilapia mossambica)*

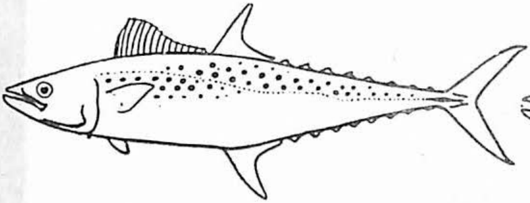


Indian Mackerel *(Rastrelliger kanagurta)*

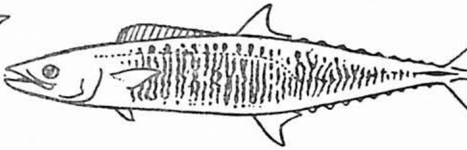
PLATE—XV



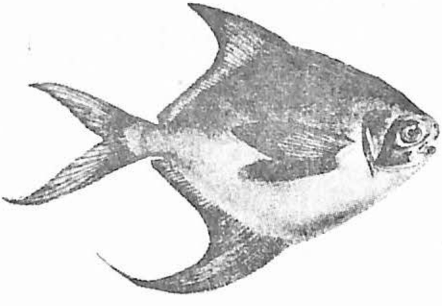
Ribbon Fish *(Trichiurus savala)*



Seer Fish *(Scomberomorus guttatus)*

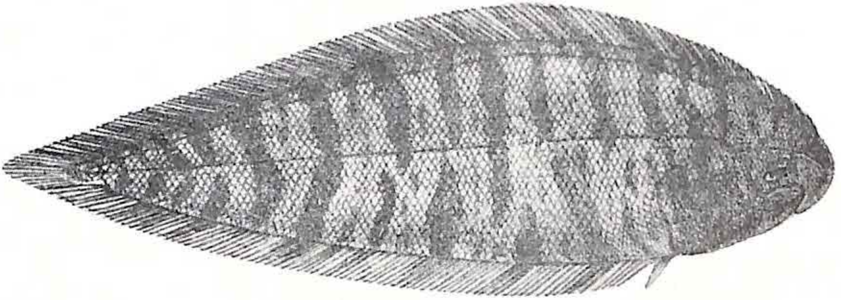


Seer Fish *(Scomberomorus commerson)*

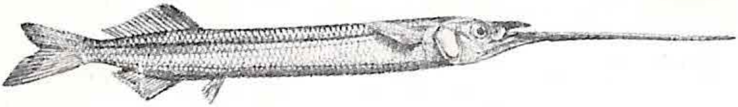


Silver Pomfret *(Stromateus argenteus)*

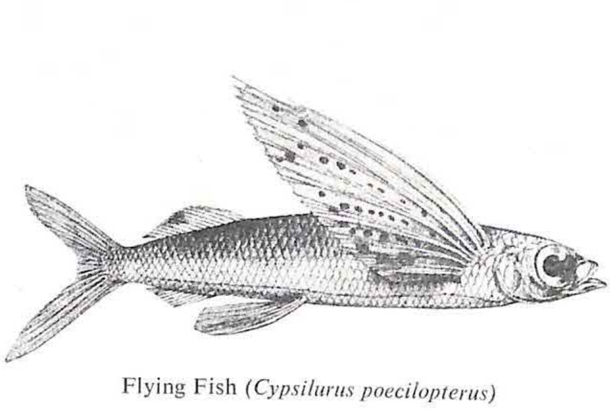
PLATE—XVI



Sole *(Cyanoglossus semifasciatus)*



Half-beak *(Hemiramphus georgii)*



Flying Fish *(Cypsilurus poecilopterus)*

Found in the seas of India up to China. Offers minor fishery in the Chilka Lake region and all along the Coromandel coast and on the Kerala-Malabar coast also. Excellent as food.

Sillaginopsis—panghs (Ham), *Sillago domina*, of Day

Tamil—*Yarra-soringa;* Oriya—*Touldant*

Abundant in the Bay of Bengal and ascending the Gangetie Delta as well as the Orissa coast. Caught in abundance in both Bengal and Orissa where it contributes appreciably to fisheries.

Family: *Lactaridae* (BIG-JAWED JUMPERS)

Perch-like fishes with compressed body, scales cycloid; mouth large; dorsal fins two, first dorsal with 7 or 8 weak spines. There is only one genus and one species in India.

Lactarius lactarius (Sch) or *Lactaruus delicatulus* Day

Commonly called white fish.

Telugu—*Sundumu;* Tamil—*Guthipu;* Kannada—*Adai-meenu;* Malayalam—*Adavu, Purruwah*

Body lead coloured on back upto lateral line. Maximum length 25 cm. Esteemed as food fish. Moves in shoals and available throughout the year, although the peak season is from June to December.

Family: *Carangidae* (HORSE-MACKERELS)

Includes typical carangids and allied fishes like chorinemids, pilot fishes and darts. Body more or less compressed, covered with thin cycloid scales, occasionally naked. Scales on the lateral line enlarged and anal with two spines. Caudal fin forked and powerful. There are several well-known species distributed along both the east and west coasts of India.

Selar *Caranx crumenophthalamus*, (Bloch)

Marathi—*Labi;* Kannada—*Bunguda hedday;* Malayalam—*Chamban*

Body silvery above, becoming golden below. Caudal fin tipped black. Commercially important as dry or cured fish on the Malabar coast.

The other notable species are *C. chrysophrys*, *C. melampygus*, *C. djeddaba*, *C. leptolepis*, *C. kurra* and *C. rottleri*.

A second important genus of carangids is *Chorinemus* (Syn *Scomberoides*) found in the Bay of Bengal and the Indian Ocean as far as the China Sea.

Scomberoides lysan (Forsk.)

Hindi—*Paras;* Tamil– *Toal-parah;*

A large-sized fish with 6-8 large brown spots resembling finger-prints above the lateral line. Tip of the dorsal fin black.

Other well-known species are *S. sanctipetri*, particularly abundant on the Andhra coast; *S. tala* and *S. tol*.

Family: *Formionid* (BLACK POMFRETS)

Formio niger, Bleeker, syn. *Stromateus niger* of Day

Marathi—*Halwa;* Telugu—*Nala-Sanda-wah;* Tamil—*Curoopevowal;* Kannada—*Chandratya;* Malayalam—*Karar-woolee, Karuppavoli.*

Genus Formio is more closely related to carangids, although for commercial purposes it is grouped with stromateids. Black pomfret is considered a good food fish, being rich in protein, fat, calcium and phosphorus.

Family: *Coryphaenidae* (DOLPHIN FISHES)

Body elongate and compressed. Scales small. Mouth large and oblique: dorsal fin long and originating on head, caudal fin deeply forked.

Coryphaena hippurus Linnaeus

Tamil—*Badahlan*

A pelagic fish, carnivorous and voracious. Widely distributed in open, warm seas. Body greenish, becoming golden on sides and below covered with small blue spots which are larger on chest.

Average size 90 cm. Maximum size 150 cm. Caught in small quantities on the Andhra coast.

Family: *Lutianidae* (SNAPPERS)

Predacious marine fishes with brightly coloured body compressed; mouth fairly large; dorsal fin with 10-12 spines. There are several species of which six are well-known and are good edible fishes.

Lutianus argentimaculata, (Forsk) or *L. roseus*, Day

Commonly called red snapper, found along the Bombay and other coasts. Colour dark rose or reddish brown, dull cherry below, fins with dark edges. Other species are *L. lineolatus* (Rupp), Golden striped snapper; *L. lutjanus*, Bl. Rosy snapper; *L. malabaricus*, Bl and Sch (Malabar snapper); *L. sangunea* (Cuv) or *L. erythropterus*, Day.

Family: *Leiognathidae* (SILVER BELLIES)

Small silvery, white fishes; body compressed, with minute scales; mouth protractile. Occur in large shoals. They are dried and salted and contribute to commercial fisheries. About a dozen species are recorded in India.

Leiognathus equulus (Forsk) or *Equula edentula*, Day

This is the largest of the Indian species. Maximum length 20 cm. It contributes to the fishery resources of the Bay of Bengal.

Other well-known species are *L. insidator* (Bl). More abundant from the Gulf of Mannar to the west coast; *L. ruconius*, Ham. Common species of the Hooghly. *L. splendens* (C), abundant all along the west and east coasts.

Family: *Scianenidae* (JEW FISHES OR CROAKERS OR GHOLS)

Members of this family are important marine food fishes and provide profitable fisheries along both east and west coasts. They are moderate-sized to large fishes, mostly inhabiting shallow waters. Body elongate with small or moderate scales. A deep notch between the first and second dorsal fins. About 10 species are well-known. They fall under several generic names.

Sciaena dussumieri (Val) syn. *Umbrina dussumieri* of Day

Tamil—*Tarukattelee*

Found in Madras and Bombay. Length 20-23 cm. Colour dark brown and coppery to black, shot with gold.

Pseudo-sciaena coibor (Ham.) *Sciaena elbeda* Day

Tamil—*Vella-katteelee*; Malayalam – *Kora*

Occur in the seas, estuaries, tidal areas of rivers. A large-sized jew fish, attaining 152-183 cm in Bombay area, while those in other places tend to be smaller.

Other species are *P. diacanthus* (Lacep), *P. sina* (Cuv) and *P. soldado* (Lacep).

The genus *Johnius* includes four noted species, namely *Johnius belengeri* (Cuv), *J. carutta* Bloch and *J. dussumieri* (Cuv) and *J. osseus* (Day).

A very important genus of the family Scianenidae is *Otolithes brunneus*, popularly known as *Koth* in Bombay. It provides a flourishing fishery on the coast of Maharashtra State. Body brown along back and rest golden. Fin grey or blackish. Attains about 60 cm, although the average specimen is about 45 cm. Two other species that occur are *O. argenteus* C. and *O. maculatus*.

Family: *Cichlidae* (Chromides)

Perch-like fishes, which include the Pearlspots, Orange chromides and Tilapia, which are all highly esteemed as food. Body compressed, covered with ctenoid scales. Dorsal fin with numerous spines; anal with three or four spines.

Etroplus suratensis Bloch

Hindi—*Pitulkas;* Telugu – *Cashimera;* Tamil—*Karassar;* Malayalam – *Karimeen*

Popularly called 'Pearlspot' on account of the opaque white spots, resembling pearls, all over the body. Colour greenish or deep purple with eight vertical bands across the body. Maximum length about 30 cm and weight 1.4 kilogramme. Pearlspots are held in great esteem on account of their delicate flavour. They are well-suited for rearing in tanks and lakes. Their palatability, hardihood, non-predatory habit, parental care and nest-building are qualities that lend them to successful rearing in inland waters.

Etroplus maculatus Bloch, Orange chromides

Tamil—*Boorakas;* Malayalam—*Pallathi*

Found around the coasts of South India, they are very common in paddy-fields, small ponds, tanks and even in ditches of water in Kanara, Malabar, Kerala and Madras. Body yellowish toning to green on the back, with rows of golden spots, Although small in size, they are considered good for eating.

Tilapia mossambica Peters

An exotic species introduced into India in 1952 by the Central Marine Fisheries Research Station, Mandapam, South India. Its original home is Africa. It has also been introduced into several places in South-East Asia, like Thailand, Malaysia, etc. It thrives under cultivation and is a prolific breeder.

It grows to about 35 cm. Like Pearlspots, it can be cultivated without much difficulty in small tanks and ponds by farmers. It is extensively tried in Kerala and is a valuable source of proteins to its people who are predominantly rice-eaters.

Family: *Trichiuridae* (RIBBON FISHES)

As the common name suggests, these fishes are ribbon-shaped, having a very thin body flattened from side to side and about 30 cm or more in length. Dorsal and anal fins narrow with numerous soft rays. Caudal fin absent. The trunk tapers to a long filamentous structure, which trails along as the fish moves. Marine in habits, it enters estuaries. There are three important species in India.

Trichiurus haumela (Forsk).

Bengali—*Rupa-patia;* Marathi—*Pitiurti;* Telugu—*Savallu;* Kannada—*Pambole;* Tamil—*Savalai;* Malayalam—*Velli-thalayan*

Common in the Arabian Sea and extends on to the Indian Ocean and beyond. Length about 90 cm.

The other two species are *T. mutius*, Gray, which is more common in the Bay of Bengal, and *T. savala* (Cuv) more common in Kerala, Konkan, Maharashtra and Orissa.

Ribbon fishes rank fourth in marine fisheries. They are mostly sun-dried for the market.

Family: *Scombridae* (MACKERELS)

Mackerels are a very important group of commercial fishes, ranking second in annual tonnage of marine fishes landed. They move in large shoals and are esteemed as food. Mackerels are fishes with fusiform body covered with minute scales. A characteristic feature is the presence of 5-7 detached finlets behind dorsal and anal fins. There is only one genus and one species in India.

Rastrelliger kanagurta (Cuv) or *Scomber microlepidotus*, Day

Marathi—*Kaula-gedar;* Tamil—*Kanan-keluthi;* Kannada—*Bangadei;* Malayalam—*Ayila*

Length ranges from 20-30 cm. Weight about 90 grammes. There is a flourishing industry on the west coast of India, particularly in the Bombay to Karwar area.

Family: *Cybidae* (SEER FISHES)

Seer fishes are famous as game fishes as well as for the excellence of their edibility. They are comparatively large, fast-swimming, carnivorous fishes predating on smaller fishes such as sardines and mackerels. There are three or four important species in the seas around India.

Scomberomorus commersonii (Lacep) or *Cybium commersonii*. Day

Bengali—*Champa;* Marathi—*Tuvar anjari;* Telugu—*Konema;* Tamil—*Mahwu-laachi;* Kannada—*Arkulai;* Malayalam—*Aykora*

In Bombay it is known as *Surmai*.

Beautifully-shaped body, with dorsal and ventral profiles equal and gradually tapering to a slender caudal peduncle. Caudal fin with two large and equal lobes. Colour blue along back, abdomen silvery white, length up to 150 cm.

Other species are *S. guttatus* (Sch.) (*Cybium guttatum* Day) abundant in the Arabian Sea and the Bay of Bengal, *S. kuhli* (Cuv) and *S. interruptus.*

Family: *Stromateidae* (POMFRETS)

Pomfrets are famous throughout the east. They are sometimes referred to as 'Butterfishes' on account of their soft flesh and delicate flavour and are therefore highly prized as food fishes.

Body ovate, compressed from side to side and covered with thin, small scales. Dorsal fin with a distinct spinous portion, which is hidden in the skin. Represented in India by two species.

Stromateus sinensis Day, is the white pomfret.

Bengali—*Chanda;* Marathi—*Chandava;* Telugu—*Chandura;* Bombay—*Saranga;* Tamil—*Mohang-vavval;* Malayalam—*Vella-arwoolee*

Occurs throughout the Indo-Pacific region. Body ovoid, deep greyish to light brown, grey and silvery below.

Stromateus argenteus (Euphr) or *S cinereus*, Day

Commonly referred to as Grey or Silver Pomfret. Upper parts silvery grey, while head and body have fine black spots over a silvery background. A dark spot on the opercle.

Order: THUNNIFORMES (Tunas or Thunnies)

Tunas are world famous, pelagic fishes of oceanic waters. They resemble mackerel in shape but are very large in size, sometimes weighing 80-82 kilograms. Dorsal and anal fins followed by 6-9 detached finlets. Scales minute or absent. A unique feature of the meat (flesh) of Tunas is its red colour, which is due to special skin blood vessels. The fish has "a mighty cutaneous vascular system connected with the vascular plexus developed in lateral muscles. These portions of the lateral muscles situated on both sides of the vertebral column are dark red." (Borg 1947).

Tunas are economically important and support canning industry in foreign countries. But in India they are one of the least exploited fish groups, hardly reaching 2% of the total marine fish catch. In countries like Japan and U.S.A., large scale tuna-fishing with the aid of power boats has been long established. Taiwan and Thailand also are tapping Tuna resources in the Indian Ocean.

However, with the expanding fishing industry in India, there is a growing interest in tunas, being capital intensive. They are caught by lines 400-500 metres long, using sardines as baits. The main centres are the islands of Maldives and Lakshadweep, and also Kerala State, which contributes 55.3% of the total tuna-fishing in our country.

Crafts or boats employed in tuna fishery are varied. Generally, they are small, mechanised boats measuring 6-15 metres long. Tuticorin type, a more advanced model of curved-out wooden boat is used in and around Tuticorin in the southern tip of the Indian peninsula. Ordinary country boats, dug-out canoes, even Catamaran are popular. Gears used are hooks and lines, drift gill-nets, purse seines and shore seines. Attempts are being made by the Government and private industrialists to exploit the rich tuna zones by the introduction of deep sea fishing vessels with appropriate modern equipment.

About a dozen species are represented in the Indian Ocean, only the more important ones are mentioned below:

Thunnus alalunga (Bonnatere) commonly called Albacore. Moderately robust body. Pectoral fin is very long. Upper part of body metallic blue, lower side and belly silvery. Length 40-100 cm.

Thunnus albacares (Bonnaterre) or Yellow Fin. Body elongate. Dorsal side metallic blue or blue black. About 20 broken vertical lines. Fins yellow. Length 50-100 cm.

Thunnus maccayii (Castelnau) Southern Bluefin. Body large and fusiform. Dorsal side bluish black. Lower side and belly silvery. Pale transverse lines alternate with dots on sides. Length 160-200 cm.

Euthynnus affinis (Cantor) or *Thynnus thunini* of Day. Little Tuna or Mackerel Tuna. *Surly* in Tamil. Body elongate,

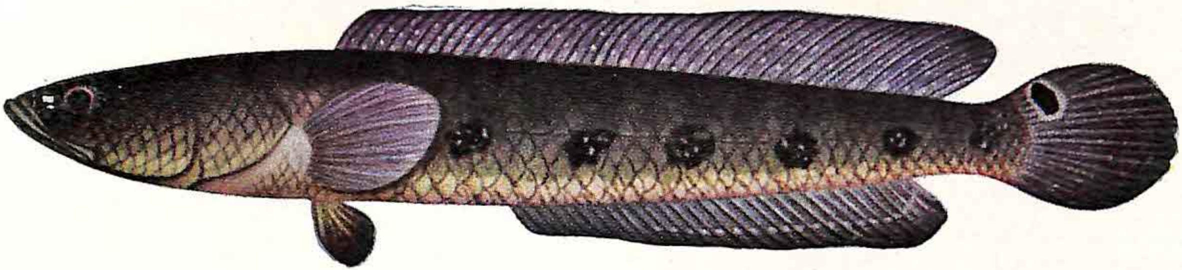


Plate 6 Snake-head *(Channa marulius)*

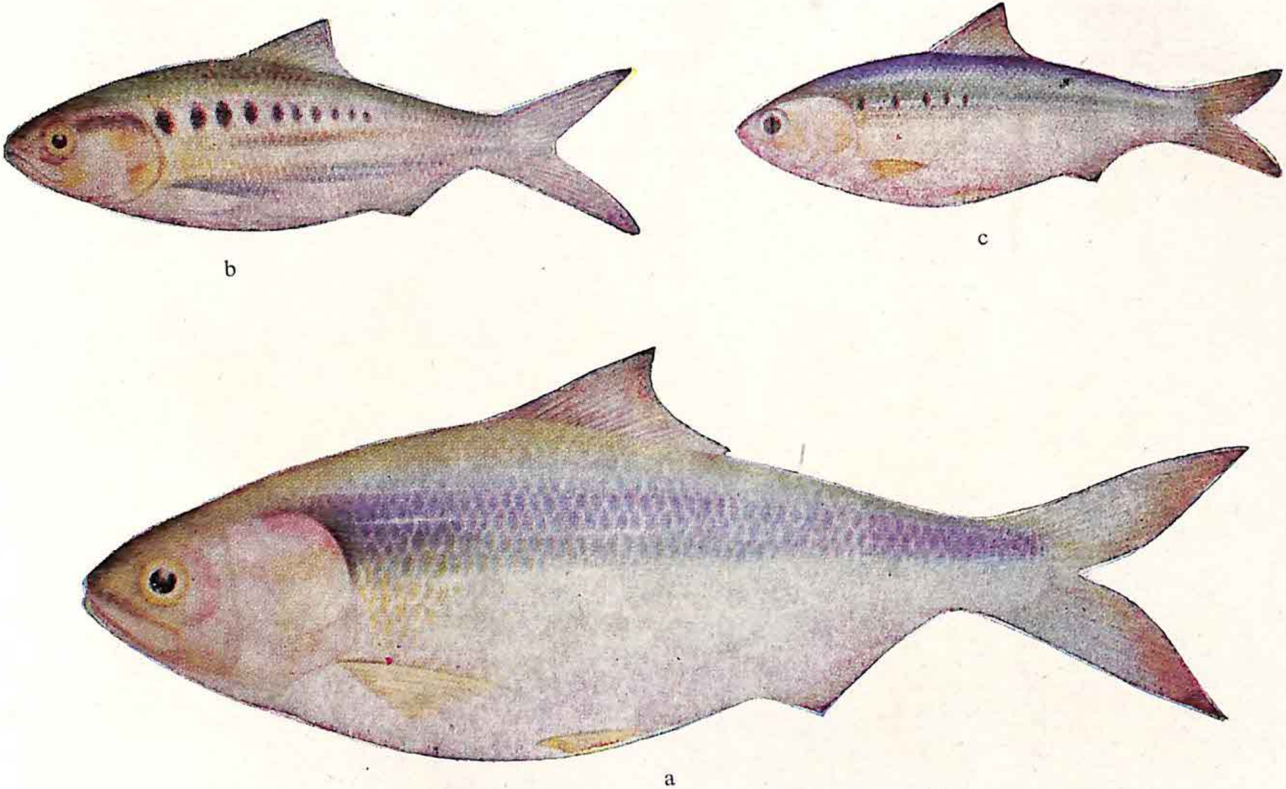


Plate 7 *Hilsa ilisha* (a. adult; b. and c. young ones)

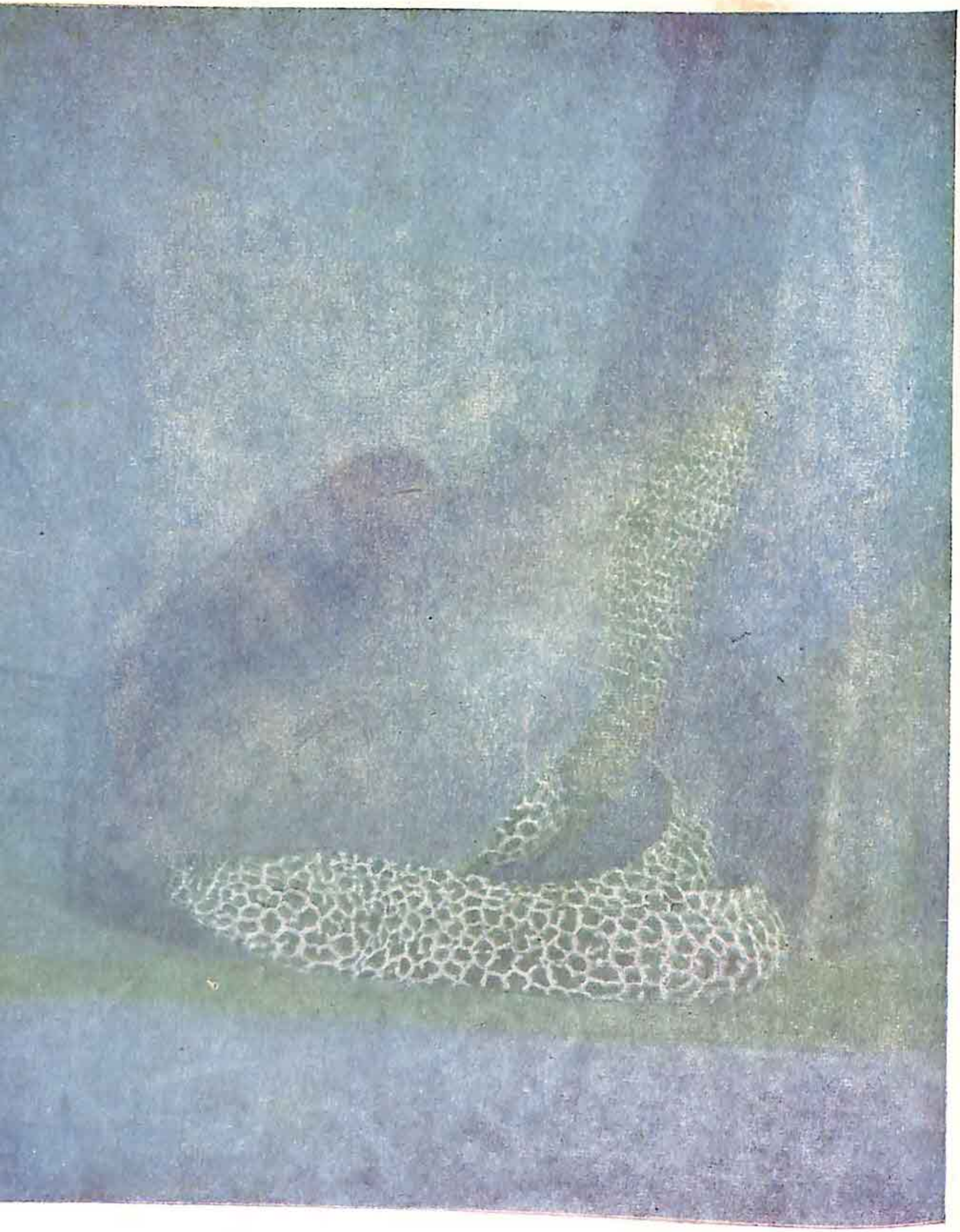


Plate 8 Spotted Eel *(Muraena punctata)*

fusiform and robust. Black spots between pectoral and pelvic fin. Number of broken wavy lines on the dorsal side. Length 40–60 cm.

Katsuwonus pelamis (Linn) Striped Bonito or Skipjack. Body robust, rounded and elongate. Dorsal side metallic blue with violet, belly silvery with 3–5 longitudinal stripes. Length 40–86 cm.

Auxis thuzard (Lacepede) Frigate Tuna. Body robust slightly compressed laterally. Back bluish, head dark. About 15 or more narrow oblique to nearly horizontal black bars extending to lateral line. Length 25–40 cm.

Order: POLYNEMIFORMES

Tropical, marine and estuarine fishes, often entering rivers. Two separate dorsal fins, first with 7 or more flexible spiny rays; caudal fin deeply lobed. Lateral line extends to the tail. Scales ctenoid.

Family: *Polynemidae* (Thread-fins or Indian Salmon)

The pectoral fins are placed low down and divided into two portions, the upper fixed to the first two radial bones, the lower consisting of several free filaments attached to the fourth radial; the third radial is devoid of fin rays. The free filaments are organs of touch and the number varies from species to species. It is from this peculiar feature that the common name 'thread fins' arises.

In size, Polynemids vary from 15 cm to 1.8 m and maximum weight recorded in large specimen is around 140 kg. Highly esteemed as food. Air bladder used in the production of isinglass. About a dozen species are found in the Arabian Sea, Bay of Bengal and the Indian Ocean; the more important ones, are listed below.

Polynemus paradiseus (Linn) syn *Polynemus paradiseus* of Day.

Mango fish. Bengali *Tapasee*. Found in coastal and estuarine waters of West Bengal and Orissa. This species is abundant in the Hooghly river ascending upto 240 km for breeding. Body golden, shaded grey along back and fins. Length 15-25 cm. Highly esteemed as food in W. Bengal.

Eleutheronema tetradactylus (Shaw) syn *Polynemus tetradactylus* of Day. Plate XIII. Popularly called the 'Indian Salmon'. Bengali — *Guchhia;* Marathi — *Rawas;* Telugu — *Budathamaga;* Tamil—*Pozzkkala;* Kanarese—*Vameenu;* Malayalam—*Bahmeen.*

Widely distributed in the seas from India to China. Body silvery green, yellowish white on the sides and abdomen. Length 1.8 m. Maximum weight recorded 140.6 kg. Relished as excellent food.

Polydactylus heptadactylus (Cuv) syn *Polynemus heptadactylus* of Day.

Malayalam — *Bahmeen.*

Found in seas from India to Malaya. Average length 15 cm. Though small in size, it is considered as a tasty fish in Malabar.

Polynemus indicus (Shaw) syn *Polynemus indicus* of Day.

Popularly referred to as 'Giant Thread-fin'. Known in Bombay as '*Dara*'. Marathi—*Bhat;* Tamil—*Thahlunkala;* Malayalam—*Yeta;* Oriya—*Sahala.*

Found mostly in seas, enters estuaries and rivers occasionally. Length upto 1.2 m. Weight around 9 kg. (maximum). Highly esteemed as food. Air bladder large and yields the by-product isinglass.

Order: PLEURONECTIFORMES (or HETEROSOMATA, flat-fishes)

This order consists of the halibuts, flounders and soles; its members are flat, like the tongue, from which feature their common name flat-fishes or tongue-fishes is derived. They are bottom-living and their upper side which is exposed is coloured, while the lower side is white. Dorsal and ventral fins are long and confluent with caudal. Both eyes are situated on the upper side. Mouth is asymmetrical. The group is commercially important, being in demand as food fishes. Halibuts are a source of valuable liver oil, particularly in Europe. In India, the sharks and rays have been found to yield better quality of liver oil. The order includes four families with several well-known genera.

Psettodes erumei (Schn.)

This is the typical halibut. The fish has a symmetrical body with a large mouth and well-defined teeth, pointing to a carnivorous habit. Found throughout the Indo-Pacific region. Upper side blackish or brownish. Eyes may be found either on the right or left side. Length about 40 cm.

Pseudorhombus is a typical example of a flounder. It is a flatfish with an ovoid body and eyes always on the left side. *Solea* are flat-fishes with eyes on the right side. *Solea ovata*, Richardson, found from the Malabar coast to South China seas. *Cynoglossus*, popularly called Tongue soles, are flat-fishes with eyes on the left side and are a large family.

Cynoglossus semifasciatus (Malabar sole) is common on the west coast.

Flat-fishes are relished as food and they are ranked as one of the fifteen important commercial groups in India.

Order: APODA (ANGUILLIFORMES) Eels

Eels, snake-like fishes, noted for their periodic migration and interesting life-history, are important commercially. Body long and cylindrical. Median fins narrow and long. Pectorals small and pelvics absent. Fins supported by rays, spines being absent. The eels of the Indian Ocean fall into four families *Anquillidae* (common eels), *Muraenesocidae* (sea eels), *Ophicthyidae* (snake eels) and *Muraenidae* (Moray eels).

Anguilla bengalensis (Gray and Hardw)

Marathi—*Ahir;* Telugu—*Malungulu;* Tamil—*Serampambu;* Malayalam—*Maniangal*

The most common eel, well-known in the Gangetic estuaries, the Bay of Bengal, the Indo-Pacific region to the seas of China and beyond. Brownish in colour with or without spots on the back and yellowish below. Tail long. Attains a length of 120 cm.

Eel Culture in India—see Bull. 23, 1980 MFIS

Anguilla bicolor McClelland, is a smaller species, 60 cm long found in the Indian seas.

Family *Muraenesocidae* consists of sea-eels, which enter estuaries and rivers. They are esteemed as food fishes and grow to a large size, thus affording a good fishery. Body long with compressed tail. Snout elongated with a large mouth and powerful teeth, carnivorous.

Muraenesox cinereus (Forsk.)

Bengali—*Bam;* Marathi—*Wam;* Tamil—*Vilangu;* Malayalam—*Pambu-meen*

Found in seas and estuaries, more abundant in peninsular India. Colour silvery to white. Length up to 150 cm. The other two common species are *M. talabon* (Cuv) and *M. talabonoides* Blkr.

Family: *Ophicthydae* includes the burrowing eels of estuaries and estuarine lakes. Body naked, dorsal and anal fins are reduced; pointed tail helps in burrowing in sandy bottoms.

Pisodonophis hijala Ham. (*Ophicthys boro* of Day)

A typical example of snake-eel inhabiting the Bay of Bengal on to the seas of China. Migrates into rivers. Maximum length 60 cm. Burrows into mudbanks, bunds, etc. and causes havoc to farmers.

Family: *Muraenidae* (MORAY EELS)

Typical marine eels inhabiting shallow waters and coral reefs. Body rounded; skin thick and scaleless. Brightly coloured, mouth large with powerful teeth; pectoral fin absent.

Three well-known species are found in the Indian seas.

Muraena punctata (Bl and Schn)

Spotted and large-sized eel. Tail as long as trunk. More common along the Coromandel coast.

Gymnothorax favigineus (Bl and Schn). Abundant on the Bombay coast. Average size 75 cm; colour yellow.

Thyrsoidea macrurus (Bleeker)

Tail long and prominent. Colour brown. Found on both west and east coasts of India.

Order: BELONIFORMES (GARFISHES, HALF-BEAKS AND FLYING FISHES)

Fishes with elongated body with prominent beak-like jaws as in typical members like garfish (*Belone*) or half-beak *Hemiramphus*. All the fins are well-developed, the dorsal and anal fins are posteriorly situated and opposite each other; caudal deeply forked. Scales thin, cycloid and deciduous. All members are noted for their power to leap in the air, particularly the flying fishes which can glide over a distance of 1.8 metres or more. They are excellent as food fishes and feature in the list of marine fisheries of India. Three families are distinguished.

Family: *Belonidae*

Includes typical garfishes, where both the jaws are long and equally developed.

Strongylura strongylurus (V. Hass) (*Belone strongylurus* of Day)

Marathi—*Tol;* Telugu—*Muddera;* Tamil—*Vellai-murrel;* Malayalam—*Pallankoli*

Widely distributed in the Indian Ocean extending to the seas of China. Grows to 60 cm long. Feeds on small clupeids, prawns and crabs. Moves in shoals and affords a good fishery on both east and west coasts.

Xenentodon cancila, Ham. or *Belone cancila* of Day

Hindi—*Kawa;* Bengali—*Kankle;* Telugu—*Vaddla-mukku;* Tamil—*Kokkumeen;* Kannada—*Konti;* Malayalam—*Kolan*

Body round, somewhat stout and robust, a silvery streak with black margin from eye to tail. Grows to 50 cm. Esteemed as food. It is a fresh water species found in India, Burma and Sri Lanka.

Family: *Hemirhamphidae*

Includes the so-called 'Half-beaks', in which only the lower jaw is elongated and prominent. Body elongated, more or less compressed. Move in shoals. Good food fishes, affording a minor fishery. About 10 species are found in India.

Hemirhamphus georgii Val

Telugu—*Gonia;* Tamil—*Kozhutha, murrel;* Kannada—*Kande;* Malayalam—*Koyala*

This species is about 30 cm long, with two bands along each side, one silvery and the other black. Affords local fishery in Palk Bay on the south-east coast, where it is found abundantly.

Family: *Exocoetidae* (FLYING FISHES)

These are interesting fishes. Found in the offshore or open seas, with power to glide. Moderately elongated, compressed body, pectoral and pelvic fins elongated to form wing-like structures. They are pelagic shoaling fishes feeding on prawns and young teleosts and their eggs. They are considered as good edible fishes and provide fishery in certain seasons.

Two genera *Cypselurus* and *Exocoetus* are met with.

Cypselurus poecilopterus (Val) or *Exocoetus poecilopterus* of Day

The common flying fish of the Coromandel coast. Colour bluish, silvery below; pectorals with black spots. Found from the Indian Ocean to the China seas.

Exocoetus volitans Linn

This species is a smaller variety of flying fish, found in the Bay of Bengal, more abundant in the southern part.

CHAPTER IX

FISHERIES OF INDIA

LONG LONG ago man mastered the art of cultivation of plants for providing himself with food, clothing and housing. He also developed skill for hunting animals which supplied meat for his hunger and skin and wool for his clothing. He also discovered that fishes were a valuable source of food and he devised simple weapons like the spear, nets and traps to catch them. Fish drawings appear on the potteries and in relics of the ancient sites of human civilization like Mohenjo-Daro in Pakistan, Harappa in India, the Nile Valley in Africa, Babylon in West Asia and Athens in Greece. Some of these drawings portray fishing boats, traps and nets, indicating that even in those ancient days man was familiar with the practice of fisheries.

The importance of fish as food has been understood by man from antiquity. Fish is found abundantly in all natural waters. It grows without his labour and he reaps where he sows not. In shallow waters, he could use a spear or devise a simple net or basket for trapping. Fishing appeared to him as a simpler method than hunting big wild animals, where speed and courage were required. Like meat, fish was perhaps eaten raw by primitive man, who found it tasty and nutritious. Even today, people of Japan, the Philippines and other islands in the Pacific Ocean eat raw fish. The importance of fish in diet lies in the chemical composition of the flesh, which is rich in protein and minerals like calcium, phosphorous and iron. Some fishes in addition have varying quantities of fats and oils.

In spite of the various advantages of fish as a valuable source of food, its availability is rather restricted in India on account of the limited fishing industry. This fact can be best illustrated if we compare the annual catches of various countries expressed in metric tons. Japan 4.7; U.S.A. 2.9; U.S.S.R. 2.6; China 2.5;

Norway 2.1; Canada 1.07; U.K. 1.05. India with its large water resources has only about 1.10 metric tons of fish-catch per year.

The consumption of fish per person in India is about 1.52 kg per year, which is perhaps the lowest in the world. Although fishes are abundant in our seas, rivers and lakes, they have become popular only in those states which are bordered by the sea or where large rivers and their tributaries flow. With a growing population and lack of facilities like transport and refrigeration, the interior regions of the country have little or no supply of fresh fishes.

Indian fisheries till 1947 (the year of political Independence) followed ancient modes and practices. Men who know the art of fishing belong to particular castes. Boats are fashioned on old primitive ideas. Fishing nets and tackles are what were devised centuries ago and are made by hand. While countries like Japan, Norway, Sweden, Great Britain, the U.S.A. and the U.S.S.R. have marched ahead with modern boats and nets, India has remained stagnant with her age-old methods. The progress of other countries depended on the introduction of motorboats, motor transport and modern methods of preservation through the use of ice and refrigerated store-rooms and vans. All these modern amenities India lacked till about 1950.

The topic of Indian fisheries is a vast one. It shall be dealt with briefly and under the following heads:

Marine Fisheries (i) Coastal (ii) Offshore and Deep Sea
Inland Fisheries (i) Estuarine (ii) Riverine (iii) Pond Culture
Fishing Craft and Gears
Preservation, Processing and Uses

MARINE FISHERIES

COASTAL

Marine fishery resources of a country depend on a number of factors. The oceanographical features of the seas have a direct bearing on the fish fauna and the nature of fisheries. The chemical nature of the water, salt-contents and nutrients are intimately related to the production of plankton which forms the food of fishes. The currents, winds, and upwelling of oceans exercise a great influence on the movements of fishes and their young ones. Besides, the land beneath the seas (the continental shelf), its area and slope, also to some extent determine the facilities of fishing. The two main seas, the Bay of Bengal and the Arabian Sea, are radically different from each other.

The eastern or Coromandel coast has a narrow continental shelf, which declines sharply to the offshore and deep-sea waters. The circulation of the water on this coast is less pronounced. The north-east monsoon winds which sweep over the Bay of Bengal are moderate and are of shorter duration. The deltas of the large rivers flowing into the Bay, and the several coastal lakes provide estuaries with their own characteristics of fishery resources. In the Andhra zone, a certain degree of upwelling has been observed. Plankton production is comparatively poor in the Bay of Bengal. The influence of these physical, chemical and biological factors is reflected on the quantities of fish available as well as the different varieties of fish.

The west or Malabar coast, on the other hand, has higher fish production. The continental shelf is broader. The south-west monsoon is stronger and longer. The upwelling of the weters is more pronounced and brings about a better circulation in the sea. The Somali ocean current, which moves northwards from the eastern coast of Africa, sweeps around near the head of the Arabian Sea and drifts down along the west coast of India. The seasonal cycles of the waters of the Arabian Sea are more abundant, leading to higher plankton production. The effect of all these factors is a richer fish fauna, both in variety and in quantity. It is estimated that more than 75% of the total fish landings are from the west coast.

For convenience of fishery statistics, the extensive coast of India is divided inso 12 zones as follows:

1. West Bengal and Orissa
2. Andhra Coast (i) South of Gopalpur to North of Vishakapatnam
3. Andhra Coast (ii) Vishakapatnam to Masulipatnam

4. Andhra Coast (iii) South of Masulipatnam to North Pulicat
5. Coromandel Coast (i) Pulicat Lake to Cuddalore
6. Coromandel Coast (ii) South of Cuddalore to Devipatnam
7. Palk Bay and Gulf of Mannar
8. Kerala and South Malabar—Cape Comorin to Ponnani River
9. Malabar and South Kanara—North Ponnani to Mangalore
10. Konkan Coast from North Mangalore to South Ratnagiri
11. Maharashtra and Gujarat Coasts—Ratnagiri to Broach
12. Kathiawar Coast

ELASMOBRANCH FISHERY

The most important sharks of commerce are species of *Rhincodon*, *Galeocerdo*, *Carcharhinus*, *Scoliodon*, *Sphyrna* and *Stegastoma*. Among the rays, reference may be made to *Dasyatis*, *Aetobatus*, *Aetomyalus*, *Rhinoptera*, *Pristis*, *Rhinobatos*, *Rhynchobatus*.

The main areas where sharks exist are Kathiawar, Bombay, Kerala, coasts of Tamil Nadu and West Bengal. The largest commercial catches on the west coast are landed at Kodinai, Veraval, Bombay, Karwar, Mangalore, Tellicherry, Kozhikode and Trivandrum and, on the east coast, at Tuticorin, Adirampatnam, Point Calimere, Nagapatnam, Cocanada, Masulipatnam, Vishakapatnam and Contai.

Sharks are found throughout the year, but the peak season is from July to March on the west coast and from May to January on the east coast. They are usually found in waters 250–300 fathoms (45–55 metres) deep. The flat-bodied rays, however, are found in shallow waters of 10–15 fathoms (4.5–7 metres). In shark-catching, long lines and hooks baited with fish or beef pieces are usually employed from small boats on the east coast or dug-out canoes on the Malabar coast, and on the Bombay coast, large plank-built boats. In recent years, power boats have been successfully used for Elasmobranch fishery in several areas.

The chief value of sharks and rays lies in their liver oil. As food fishes, they rank lower than bony fishes on account of their 'urea' flavour. For commercial purposes, the larger the sharks, the better their livers, which yield more oil.

TELEOST FISHERY

SARDINES AND ALLIED GENERA (CLUPEOIDES)

It has already been pointed out that the clupeoid fishes are of great economic importance as a source of food and oil. There are several kinds which are extensively distributed in the Indian waters. Another factor which adds to the success of their fishery is that the clupeoids are shoaling fishes, which move in groups of thousands and thousands. A fishery is considered profitable if the per hour catch is higher per unit man-power.

The important clupeoid fishes that contribute to this sardine fishery are: *Sardinella longiceps* or oil sardine, *S. fimbriata* and *S. gibbosa.* All three species occur in very large shoals. The rainbow sardine, *Dussumiera*, and the white sardine, *Kowala*, also feature in this particular fishery.

The oil sardine fishery is more or less restricted to the west coast, the large shoals occurring in the Malabar and Kerala zones. One of the interesting features of this fishery is its fluctuations or periods of abundance alternating with scarcity. Sardines were plentiful in 1941-42; during 1942-49, they were on the decline. From 1949, the catches have gone up. There seems to be a cyclic period of glut and scarcity. The scientific basis of these fluctuations is still under investigation. The temperature of water, salinity, currents, upwelling and availability of plankton are influencing factors in maintaining fish population. The indiscriminate capture of very young fishes and of potential mothers leads to depletion of stocks.

The sardine season extends from August to March on the Malabar-Kerala coast with the peak period from September to January.

The gear used for sardine fishery is the gill nets, which are of two different kinds. The first one is locally known as *Mathi-chala-vala* and the second *Mathi-holli-vala*, a specially evolved seine net. The shoals are sighted by various attendant signs, such as the excitement of seabirds in the vicinity and the presence of sharks and porpoises in the neighbouring waters.

All sardines are tasty fishe and are relished both by the rich and the poor. They are best when freshly cooked. They can be preserved by salting or canning. Canning factories have been established in certain part of the Malabar and Kerala coasts. Oil extraction is a flourishing trade too. Surplus fishes are often converted into fish-meal or manure.

The second important clupeoids are *Anchovies* or Engraulids. The important species are already listed in the section on Indian fish fauna. *Engraulis mystax* and *Engraulis purava*, the well-known anchovies, are slender and bony fishes and are best when dried or converted into a paste. Fishery is found in Malabar, South Kanara and Kerala as well as Bombay zones. The season extends from August to December.

Other allied genera like *Pellona, Ilisha, Setipinna, Coilia, etc.,* although they contribute to the sardine fishery in general, are less well known.

MACKEREL FISHERY

Amongst the marine bony fishes of India, mackerels enjoy the second position in importance as a commercial group contributing high tonnage per year. The Indian mackerel, *Rastrelliger kanagurta*, is the only species of the genus found in the seas around the sub-continent. The chief centre of mackerel fishery is the area between Ratnagiri in Maharashtra and Quilon in Kerala State. On the east coast, it appears sporadically near Mandapam, Madras, Kakinada, Vishakapatnam and parts of Orissa.

Mackerels appear in different seasons in different places along the west coast. In the area between Cape Comorin and the Ponnani river, the shoals occur at irregular intervals from August to February. Boat-seines with dug-out canoes are employed for catching fish. The second area between the

Ponnani river and Mangalore is the most important one and the season begins early in August or September and lasts till March or April. The craft used are dug-out canoes with boat-seines or *Odam-vala* or gill nets known as *Ayila-chala-vala*, both of local design and made by hand. The third area lies between Mangalore and Ratnagiri, also a busy centre for mackerel fishery. Here the season starts a little later, i.e. from October to November, extending to February or March. Gill nets locally known as *pattabale* and a highly specialised shore seine known as *Rampani* are in use for the capture of mackerels. Rampani is a long shore seine, operated by about 80 men and assisted by five dug-out canoes. The indigenous boats and gears can operate in an area of four kilometres only from the shore.

On account of the economic importance of this fish to the fishing industry, the Government of India has established a research station at Karwar (Maharashtra State) for the intensive study of the biology of the Indian mackerel. It is pelagic in habit and moves in massive shoals which are easily visible from a distance, During daytime, the shoals appear as dark patches, where the water is thrown into ripples. At night the fishes are visible by the emission of light from their phosphorescent bodies.

Mackerel is an excellent food fish, particularly when fresh. A large percentage (40%) of the catch is preserved in ice and despatched to various inland towns by train and truck. It is estimated that about 60% are salt-cured or pickled, of which a portion is consumed in the country, while the balance is exported to nearby countries like Sri Lanka. When the catch is very abundant, the surplus is converted into manure. The bulk of fins, gills and guts are utilised in the preparation of fish-meal.

BOMBAY DUCK FISHERY

Bombay duck is the popular name of *Harpodon neherius*, Ham. (a Scopolid), a well-known commercial fish in India. The 10% of marine fishcatch fishery is very important on the Bombay coast from Ratnagiri to Broach (Saurashtra), ranking next to the mackerel in total annual tonnage. Bombay ducks are migratory fishes and are spotted on the eastern coast as far north as Orissa and Bengal.

The fishery season on the Bombay coast lasts from the end of peak October-December to the end of May-June The gear used is a large bagnet (dol net) operated from boats plying within a distance of 6–8 kilometres offshore. About 20% of the catches is consumed fresh by the fishermen and other communities of the Bombay region who relish this fish as food, while the rest (80%) is sun-dried. Length of catch fishes—90 mm–300 mm.

RIBBON FISHES

From the comparative data of fish landings from the sea, Ribbon fishes (*Trichiurus*) contribute a fairly large precentage of the total catch per year—as much as 3,700 to 3,800 tons, There are three species prevalent in the Indian seas and all of them are carnivorous and voracious feeders. Each species moves in a separate shoal and at a different time of the year. They are widespread along the entire coast and caught by seine nets in all zones. However, the most important zone is that of Kerala, while Madras and Andhra coasts come next. Ribbon fishes are eaten in the fresh condition mostly by the poorer people along the coast. About 40-45% are sun-dried and soid as cured fish.

JEW FISHES

Jew fishes (Sciaenids) contribute a sizeable proportion to the marine fishery, particularly on the Bombay and Kathiawar coasts. The fresh water members of the family are also considered important in the estuarine and fresh water fisheries of the Ganges and its delta.

Although the family is composed of a large number of species, only a few are of economic value. In Bombay where these fishes are most abundant, the local fishermen identify them under three groups. They are: (i) *ghol* consisting of *Pseudosciaena*. the large variety; (ii) *koth* or *Otolithoides brunneus*, Day; and (iii) *dhoma*, which includes all small sciaenids.

In the Gangetic region, *Pama pama* Ham. and *Pseudosciaena coibor*, Ham. are the most important species of commerce.

Sciaenids, besides being a valuable source of food, are noted for their large air-bladders which when dried yield *isinglass* of commercial importance.

POMFRETS

Pomfrets or butterfish (Stromateidae) are now assigned to three different genera. The true pomfret is the grey-coloured one, belonging to the genus *Stromateus*, while the white pomfret is *Chondroplites*. The black pomfret, *Formio*, is probably not a true member of this family. However, for commercial purposes, they are all grouped together under one common name. Pomfrets on account of their soft flesh, delicate flavour and absence of hard bones are relished highly as food. They rank as one of the three best priced marine fishes in India.

The important centres of pomfret fishing on the west coast are South Kanara, Malabar and on the east coast Vishakapatnam and Nellore districts. They are also caught in the northern parts of the Bay of Bengal.

INDIAN SALMONS

The most important member of the family Polynemidae is *Eleutheronema tetradactylus*, the common 'Rawas' of Bombay or *Polynemus tetradactylus*. Three other species are also met with in Indian waters. They are carnivorous and predate on prawns, crabs and young of teleosts. The adults ascend rivers as far as the tidal reach during winter months and are found in the mouths of the Hooghly river. They occur in West Bengal and Orissa, Gopalpur and Ganjam on the east coast and Bombay and Gujarat on the west coast. On the east coast, the season is from February to May and on the west coast, the peak season is from September to November.

The gears employed are seines and dragnets in shallow inshore waters and estuaries and long lines baited with small fish are in use in deeper coastal waters.

SEERFISHES

The most important species of commerce are *Scomberemorus commersonii* Lac., *S. guttatus*, *S. kuhli* (C) and *S. interruptus* (C). Seerfishes are caught all along the coast on long lines baited with pieces of sardines or anchovies or prawns. They are greatly esteemed as food fish throughout India. They are related to the mackerel and, like mackerels, they have a reddish flesh with high fat content. Being large in size, they are often sold in cut pieces. Large quantities are salt-dried.

SOLES AND ALLIED FISHES

These fishes (Pleuronectidae) are popularly known as flat or tongue-fishes which fall into several distinct genera. Soles fishery in India depends mostly on one species, *Cynoglossus semifasciatus*, off the Malabar coast, Kerala and South Kanara. They are known locally as '*Nangu*' in the northern centre and as '*Manthal*' in the south. Besides, the Kathiawar coast is also well-known for other kinds of flat-fishes. Being a cheap variety of fishes, they are eaten by the poorer people both in fresh and salted forms. Fishery season commences all along the coast soon after the south-west monsoon and extends up to November. The gear used in soles fishery are shore seines, boat seines and castnets which are operated from canoes.

TUNAS

Tunas (Thunnidae) are world-famous pelagic fishes of oceanic waters. A large-scale tuna fishery with power boats has been established by countries like the U.S.A. and Japan, while it has been introduced into India only recently. Tunas are large fishes and are economically important for the canning industry.

Besides the above important families, carangids, silver bellies, eels, flying fishes, and red mullets (Mullidae) contribute to the coastal fisheries.

OFFSHORE AND DEEP-SEA

Beyond the area of the continental shelf lies the expansive ocean, rich in various kinds of fishes. Some of them are surface or mid-water dwellers, while others live in deeper waters or at the bottom of the sea. The exploitation of these fish fauna constitutes offshore and deep-sea fisheries. These were not given much attention in India owing to lack of mechanised or power boats and enterprising businessmen. Besides, the economic conditions of fishermen did not permit large capital necessary for power-fishing.

Around the turn of the century, however, attempts were made to survey the offshore fish fauna. Preliminary trawler surveys were done in the Bay of Bengal and the Arabian Sea, off the Bombay and Kathiawar coasts, as well as some parts of the Konkan and Coromandel coasts. These surveys revealed the existence of great wealth of fishes and located various centres of rich harvest for future exploitation.

It was not until after World War II that further attempts were made in that direction. In 1946, the Government of India established a pilot Deep Sea Fishery Station at Bombay. Several state governments like Kerala and West Bengal also set up their own marine fishery stations in subsequent years. By 1958, the Central Government added two more—one at Cochin and the other at Vishakapatnam. The scientific and technical aspects of the work are being conducted in collaboration with various foreign experts from countries like Norway, Japan and the United States. There are at present five important trawling grounds. They are located at Bombay, Cambay, Veraval, Porbunder and Dwarka.

The most important commercial offshore fishes are: Rawas (Indian salmon, *Eleutheronema tetradactylus)*, Dara (Giant headfin, *Polydactylus indicus)*. Ghol (jew fish, *Pseudosciaena diacanthus);* Koth *(Otolithoides brunneus*, a large Sciaenid), Wam (sea eel, *Muraenosox)*, Karkara (Grunters, jew fishes) and pomfrets. In addition, catfishes, rays and small sciaenids are also found among the catches.

The most profitable depth has been found to be about 20 fathoms (37 metres) and that the catches are better during the day than night and also during neap-tide than spring-tide. Trawlers are used for large-scale fishing in the offshore and deep-sea zones. Various kinds of trawling nets are in vogue, the oldest being the *Otter* type. The Japanese method of bull-trawling has been found to be more effective and is extensively used in Bombay and Saurashtra waters.

The other two experimental centres of trawling are Kerala and Bengal. In Kerala a method known as 'Dory fishing' is in use. In this, a mother ship tows out small boats to offshore fishing grounds. The actual fishing is done by use of hooks and lines. Besides, other trawling also is common. These explorations have indicated the existence of profitable perch fishery grounds in the Arabian Sea.

The most important fishes of the deep-sea and offshore areas are various species of perches like *Epinephelus* and *Lutianus* among the teleosts and *Carcharhinus* and *Pristis* among the sharks.

The deep-sea fishing stations in the Bay of Bengal are located at Black Pagoda, Sand Head, Tigerpoint, False Bay Point, off the Devi river mouth, off the Prachi river mouth and off the Baitarani river mouth. The common catches are sciaenids, perches, ribbon fishes, eels and sharks and rays.

Deep-sea fishery to be successful should have harbour and anchorage facilities, motor transport from landing places to centres of distribution and consumption; marketing and storage facilities, besides scientifically trained men. These requirements are under study by the various state governments and the Union Government. With the collaboration of experts and technical aid of countries where fisheries have advanced on scientific lines, it will be possible to establish deep-sea fisheries on modern lines in India before long.

INLAND FISHERIES

It has already been pointed out that India has a large number of rivers, innumerable irrigation canals, tanks, reservoirs and ponds. Besides, there are extensive estuaries (deltas or river-mouths), lagoons, backwaters and brackish water lakes. All these bodies of waters, both big and small, provide rich resources for inland fisheries. For convenience, these will be considered under three sub-headings: (i) Estuarine (ii) Riverine (iii) Pond Culture.

ESTUARINE FISHERIES

Estuarine fisheries are located in the mouths of the rivers Ganges, Mahanadi, Godavari, Krishna, Cauvery on the east coast and the Narmada and the Tapti on the west coast. In addition, lakes like Chilka and Pulicat and the backwaters of Travancore-Cochin in Kerala are well known. Estuaries and estuarine lakes have saline waters and only those fishes which can withstand changes in salty conditions thrive best. Some species of sardines and anchovies (e.g. *Hilsa ilisha*, *Anchoviella*, *Thrissocles*, *Nematolosa* and *Setipinna*); mullets (e.g. *Liza corsula*, *Mugil cephalus*); catfishes (e.g. *Tachysurus* or *Arius*, *Pangasius*, *Mystus*), perches (e.g., *Lates calcarifer*, *Epinephelus*), Pearlspot or *Etroplus* are the most common.

The Chilka Lake of Orissa needs special mention. It is one of the largest open estuarine lakes in India with an area of 906 sq km in the dry summer. In the rainy reason it swells up to 1,165 sq km. A channel of 23 km connects it with the Bay of Bengal. It receives most of its waters from the Daya, one of the deltaic branches of the Mahanadi. The important marine fishes are *Gerres*, *Ambassis*, *Strongylura*. *Xenentodon*, *Therapon*, *Sillago* and *Megalops*, while carps, catfishes and murrels constitute the fresh water varieties. The annual production is around 3,000 metric tons, of which 90% are exported in fresh condition and the remainder is consumed locally or salt-dried.

Another type of estuarine lake is the embanked brackish waters, which as the name suggests are protected by artificial walls or barriers. This type of fishery is best developed in Java and the Philippines. In India, it is practised in West Bengal, where it is called 'Bhasabandha' fisheries or 'Bheris'. In the estuary, lands are reclaimed by building walls or bunds to keep away floods and tidal waters. Such reclaimed lands are used for agricultural purposes for raising a crop or two. When the land is not under cultivation, it is used for rearing fishes for which purpose the shallows are filled with fresh water, which is let in through sluice-gates from the rivers. This supply of water brings with it fish and their fry which grow up in these confined and protected shallows. When they reach a good size, they are caught for the market.

Malabar is also famous for its embanked brackish water fisheries. The areas near the backwaters of Kerala, the Vempanad Kayal, have been reclaimed for paddy cultivation. There is only a single annual paddy crop from July to September. After the harvest, the bunds or walls are raised and strengthened. At high tide, sea-water is let in. Fishes and prawns in thousands are brought into these confined areas where they live and grow for about six months, when they are ready for capture. Mullets and Pearlspots are the most abundant among fishes and contribute about 20%, while prawns make up the balance.

Narakkal farm has become important in fish-rearing in India. Narakkal in Kerala was originally a swamp. It was taken over by the Government (Central Inland Fisheries Research Station) and converted into a useful farm for mullets (*Mugils*) and milk-fish (*Chanos*). The farm consists of several ponds with bunds and sluice-gates and occupies an area of 50 sq km. The fishes are let in along with the tide. *Mugil cephalus* is the predominant species and contributes about 75%. It is a fast growing fish which attains a length of 45 cm in a year.

A similar farm has been set up in South Kerala at Ayiramthengu, near Kayamkulam Lake. The farm, about 0.08 sq km in size, is utilised for *Etroplus* cultivation.

The most useful fishes for brackish water cultivation are *Chanos*, *Mugil*, *Etroplus*, *Lates*, *Tilapia* and *Osphronemus* (gouramy).

RIVERINE FISHERIES

The major rivers of India—the Indus, the Ganges, the Mahanadi, the Kaveri, the Krishna and the lesser ones—with their tributaries and canals, the inland lakes, *jheels*, *bheels*, pools, tanks and ponds all provide varied habitats for the large population of fishes. These will be considered in the order of their economic importance.

MAJOR CARPS

This group includes *Catla catla*, *Labeo rohita*, *L. calbasu*, *L. fimbriatus*, *Cirrhina mirgal*, *Tor tor* and *Puntius*.

All carps are considered as valuable food fishes and are in great demand in inland cities. They are fished intensively from September to April in all parts of northern India and contribute to the bulk of the fresh water fishes of the markets. Carps are suitable for pond culture. Pond culture is a distinct aspect of fresh water fisheries and will be considered under a separate heading.

CATFISHES

The important commercial catfishes are *Wallago attu*, *Ompok bimaculatus*, *Pangasius pangasius*, *Silonia silondia*, *Mystus seenghala*, *Mystus aor* and *Eutropicthyes vacha*. They are scaleless fishes with soft muscles and a few bones. However, there is a certain amount of prejudice against them, as they have been tabooed by the Jews. There are also misconceptions that they are either scavenging fishes or live in foul waters.

LIVE FISHES

The so-called 'live fishes' are a heterogeneous assemblage, consisting of two members of the catfish series, three or four of Ophicephalids and one of Labyrinthici. Their common feature is the presence of accessory respiratory organs which enable them to survive out of water for a relatively long time and hence the popular name 'live fishes' (see Part I, Chapter IV). In the markets, they are kept in large earthenware pots filled with water and sold alive. The popular belief is that there is a special nutritive and medicinal quality in these fishes, which are good for patients and convalescents.

The list of live fishes is as follows: *Clarias batrachus* and *Heteropneustes fossilis* of the catfish. *Channa striatus*, *C. gachua*, *C. punctatus*, *C. marulius* of the snake-heads or Ophicephalid family and *Anabas testudineus* of Labyrinthici. They contribute about 10% of the total marketable surplus of fresh water fishes of India. During the last 10 years various state governments like those of Andhra Pradesh, Tamil Nadu, Karnataka and Kerala have been trying to encourage the cultivation of these fishes in village ponds and irrigation wells where carp culture is not possible.

Mention may be made of a few other groups which feature in the fresh water fisheries of India. They are featherbacks or *Notopterus*, a few fresh water members of mullets (*Mugils*) and the fresh water eel, *Anguilla bengalensis*.

POND CULTURE OR PISCICULTURE

Fish culture is an ancient industry in India. Records of older civilization, however, reveal that it was practised at still earlier days by the Chinese and the Romans.

Culturing of certain types of fishes in wells, garden ponds or domestic and temple tanks is an old practice in India. It was popular in the north-eastern states of Bengal, Assam, Bihar and Orissa, which are the main freshwater fish-consuming areas. These states have naturally rich soil conditions, comparatively high rain-fall and innumerable confined water areas in the form of small and large ponds, irrigation reservoirs and canals. The environmental factors coupled with food habits of the people were highly suitable for fish culture of locally available fishes.

The old practice was to collect very young-ones of carps, the fry, about 4.25 cm. long and transfer them to tanks or ponds or bundhs (enclosed waters). When these grow for a year or two, they were netted for consumption.

Realising the significant nutritional values of fish in the diet of the people, various states established Fishery Departments with the aim of exploiting the vast water resources by improving fish culture techniques on scientific lines. The Fishery Departments undertook to improve the techniques for fish seed collection from river system, distribution of fish seed to interested pond-owners and also fish rearing in various types of confined water bodies.

To get the best yield of fish through fish culture the selection of proper species is important. The most suitable species are those which can grow not only fast, but also to a large size and at the same time, select fishes that neither will compete with

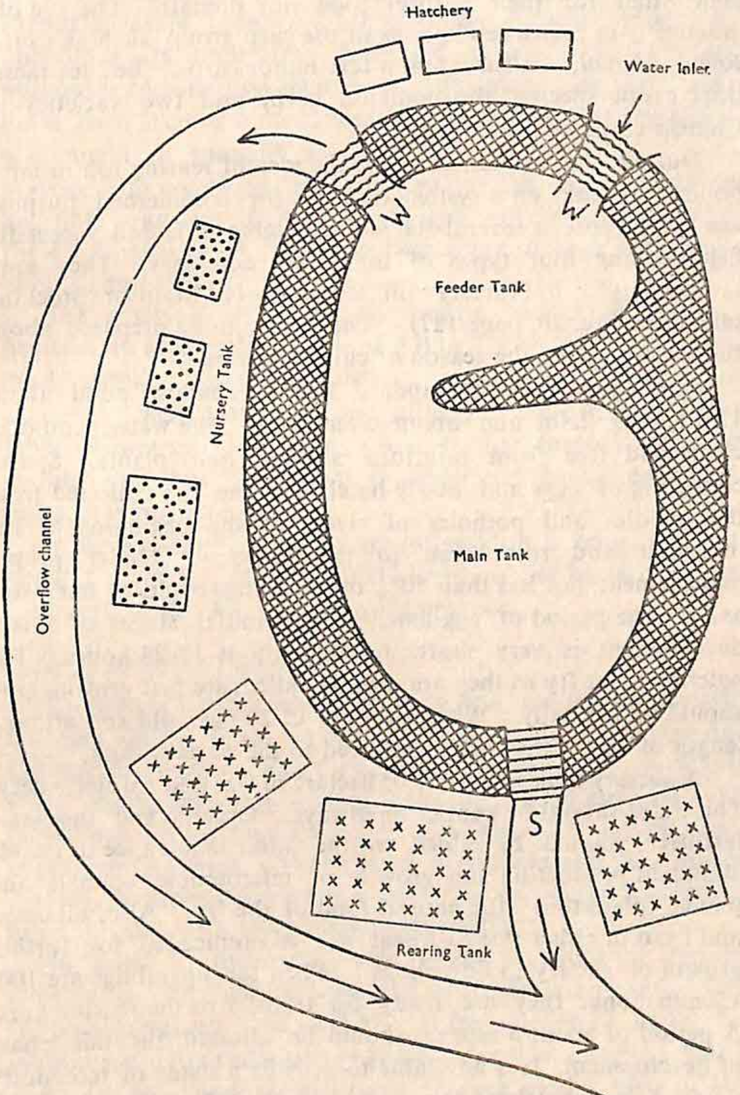


Fig. 20: Plan of a Fish Farm.
W—wire gauze; **S**—sluice gate [*after* Chowdhury, B.L. (1946)]

each other for their natural food nor predate. The age old practice is to rear a few species of the carp group such as *Catla, Rohu, Mrigal, Calbasu* and a few minor carps. Besides these, three exotic species, the common carp, and two varieties of Chinese carps are also suitable.

During the last few decades, the idea of rearing fish in large ponds and tanks on a systematic plan for commercial purpose has taken roots in several states. For large scale and successful fish farming four types of tanks are necessary. They are : i. Hatchery* ; ii. Nursery ; iii. Rearing ; iv. Main or Stocking tanks (see Fig. 20, page 127). These have to be prepared about thirty days before the season of culture begins.

A hatchery tank of standard size is a shallow pond about 13×1.5 to 2.4m and about 0.6m deep. The water should be clean and free from injurious animals and plants. Spawn consisting of eggs and newly hatched larvae are collected from the puddles and potholes of rivers at the beginning of the monsoon and transferred to the hatchery. Under proper management, not less than 50% of hatchlings could be harvested as fry. The period of egg-hatching and initial stages of larval development is very short, roughly about 18-24 hours. The hatchlings, or fry as they are usually called, are fast growing and should be fed daily. When they are 15-20 days old and attain a length of 25mm they are transferred to the nursery tank.

A nursery tank is about 0.05 hectare in size and 1.0 metre deep. The water should be kept clean always. Organic and inorganic fertilisers should be added to the water in advance to enable abundant production and growth of microscopic animals and plants (plankton)—the natural food of the fry. Also, oil cakes and bran of either rice or wheat are recommended for further growth of the fry to fingerlings. When the fingerlings are 100-150mm long, they are ready for transfer to the rearing tank. A period of about 3 months should be allowed for this phase of development. It is advisable to provide a shade of temporary roof of leaf-thatching to cut off intense light, heat, rain and predatory birds.

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*The recent practice eliminates hatchery tanks. Hatchlings are introduced directly to nursery and pond culture is 3-tiered.

The third type, the rearing tank, is larger and deeper and should measure roughly 0.1 hectare and 1.5 metre deep. The fingerlings are transferred from the nursery tank. The main purpose is to condition them before removing them to the main tank. Each evening a mock netting is practised. The fingerlings are caught in specially small-meshed net and released. This practice is to condition them to overcome the shock of capture and final transfer. In the rearing tank, the fingerlings are kept for 4-6 months where they grow bigger and sturdier and assume almost adult size.

The stocking or main tank should be 0.20 to 1.0 to 2 hectares in area with a depth of 2.0 to 2.5 metres. In a period of 12 months, the young fishes grow to marketable size, each attaining a weight of about one kilogram, and are ready for the table. However, fishes can be reared further, through the second or third year, but their growth is slower and from a commercial point, it is not economical.

If these scientific methods are followed, it is estimated that a pond can yield 3,000 to 10,000 kilograms per hectare per year, compared to 800 kilograms by old practices.

Induced Breeding Technique

As already seen, carp-fishes grow and mature in captivity, but they do not breed in confined waters. In the earlier days fish farmers used to collect eggs and hatchlings from flooded rivers during monsoon season, using indigenous methods. The collection of seeds from river system is hazardous, expensive and unpredictable owing to the vagaries of weather and flood-waters. Besides, the seeds collected can neither be sorted out species-wise nor cultivated with much economic benefits.

In order to overcome these obstacles, fisheries research workers carried out experimental work for a number of years till success was achieved in 1957. A few species of major and minor carps were cultivated in ponds or cement cisterns. Mature and ripe male and female carps of each species were injected with pituitrin, an extract of the pituitary gland (an endocrine organ popularly known as ductless gland situated at the base of the mid-brain). With the growth of embryology (study of development) and endocrinology (study of hormones and their effects on biological functions), it is possible to change the rate of reproductive functions. The administration of pituitary hormones helps to accelerate the gonadial development. In the female fishes the eggs mature and become ready for spawning while the male sheds its spermatozoa into the water, where fertilisation takes place. This method is called induced breeding.

Fertilised eggs swell up into a boat-shaped mass inside which the embryos develop. The larvae hatch out in about 10-15 hours and can be reared in a hatchery or nursery tank, as mentioned earlier. By selecting the male and female of a particular species, millions of pure hatchlings of each species can be raised.

A new kind of induced breeding is under experimentation in India. As early as 1976, the Food and Agricultural Organisation of the United Nations reported encouraging results in breeding and spawning of certain varieties of Chinese fishes by administering the use of Human Chorionic Gonadotrophin (HCG). HCG is a hormone produced by the placenta of developing embryo in the uterus and excreted through the urine of the mother during pregnancy. It is similar to Luteinizing Hormone (LH) of pituitary gland. The method has been adopted in several countries and has been found successful in promoting development of gonads, their growth, maturity and spawning. HCG has several advantage over pituitrin, the chief ones being the comparative ease of collecting and storing, besides being less expensive, In 1984, the Central Institute of Fishery Education, Bombay, conducted field trials using HCG with success in West Bengal, Haryana and Madhya Pradesh showing prolific spawning in major carps and also silver carps. However, to make the latest technique more effective, it has to be popularised among fish culturists.

Another interesting method, the 'Bundh Breeding' may be mentioned. Here the natural fish breeding habitat is simulated in the man-made environment, called the 'bundh'. Accumulated rainwater from large catchment areas of the bundh overflows through limited sluice opening. Male and female brood fishes are introduced into such bundh waters. The fresh supply of rainwater is believed to induce them to spawn naturally. Eggs and fry are collected from such bundhs and are used for further rearing and stocking.

Composite Fish Culture is a recently evolved technology to produce high yields. Instead of a single species only, five or six species of carps are grown together in one tank, five thousand to eight thousand fully grown fingerlings of different species in the right proportion are introduced in one hectare water area. As in all pisciculture practices, the tank should be kept clean. Predatory fishes and dangerous weeds may be removed by modern methods of chemical or biological control. To determine the quality of soil and water in the tank modern scientific analysis is recommended and deficiency if any may be corrected by the addition of organic or inorganic fertilisers periodically. The fingerlings should be fed daily. If all the above conditions are maintained, the yield has been found to be far superior.

Besides carps, Indian, Chinese and European, a few species of catfishes, such as *Clarias, Heteropneustes*, *Pungasius* and *Mystus* can also be cultivated. Also, the climbing Perch *Anabas*, Murrels *(Ophiocephalus* or *Channa)* and Featherbacks *(Notopterus)* are also reared as they are relished in some parts of the country and are thus of economic importance. In the Kerala backwaters, Mullets *(Mugil)*, Milkfish *(Chanos)* and Pearlspot *(Etroplus)* are extensively farmed. *Tilapia* (a Cichlid, related to *Etroplus* and belonging originally to Africa and introduced to India), is a prolific breeder and is now grown in ponds and lakes and is considered useful and beneficial for sustained culture.

Though fish farming is mainly carried out in natural reservoirs and ponds, paddy-cum-fish culture is an innovation. Rice plants, when they are a few centimetres high are flooded with water to ensure constant and sufficient supply of moisture and nutrients to this cereal. At this stage if suitable fishes are introduced, both paddy and fish are reported to yield high production. This method is practised in Bengal and Kerala to some extent.

CHAPTER X

FISHING CRAFT AND GEAR

INDIA, WITH its long sea-coast and extensive riverine and estuarine waters, has a wealth of fish fauna. The success of fisheries in a country depends on the boats that can ply in its waters and the nets that can capture its fishes. In this survey, we shall find that a large variety of boats or craft have been designed in India for use both for marine and inland fishing ranging from simple, crude rafts and canoes to well-built boats, all propelled by men. The nets or gear and other devices for catching fishes are also numerous and ingenious. But both craft and gear were invented centuries ago and have remained static and have shown little or no change or improvement in India, unlike in other maritime countries. This has hindered or restricted the exploitation of our seas and rivers. It is only in the last decade or two that some attempts have been made to use motor boats and modern steam vessels for the purpose.

The fishing craft and gear will be considered under the following heads:

Marine Fishing Craft and Gear
Inland Fishing Craft and Gear
Mechanised Craft.

MARINE FISHING CRAFT AND GEAR

MARINE FISHING CRAFT

Craft or boats used in the Indian seas are varied and of several types. On the east coast are found catamarans, masula boats, dinghis, nanku and Tuticorin boats.

Catamaran (Tamil: lashing timber) is a primitive raft, constructed by tying together several logs which are curved and shaped like a canoe. One end of the craft is shaped into a cone which rises above the water level and forms the point from where the rudder is controlled. There are four types of catamaran (a) the *Coromandel* type, probably the original Tamil Nadu type. It is made of 3-5 logs. A variation of it with 7 logs called *Kolamaram* is used in the capture of flying fish off Nagapatnam; (b) the *Orissa and Ganjam* type is made of 5 logs which are not tied together by rope, but are pegged with wood. The planks are cut in such a way that the catamaran takes the shape of a boat; (c) the *Andhra* type is a variation of the Orissa type, but larger (5-7 metres long) and made of heavy wood. The planks used in fitting the sides are strong, median logs; (d) the *Boat-Catamaran* is made up of 3 logs; shaped and fitted into a regular boat-shaped vessel. It is used around the Mandapam and Mukkur areas.

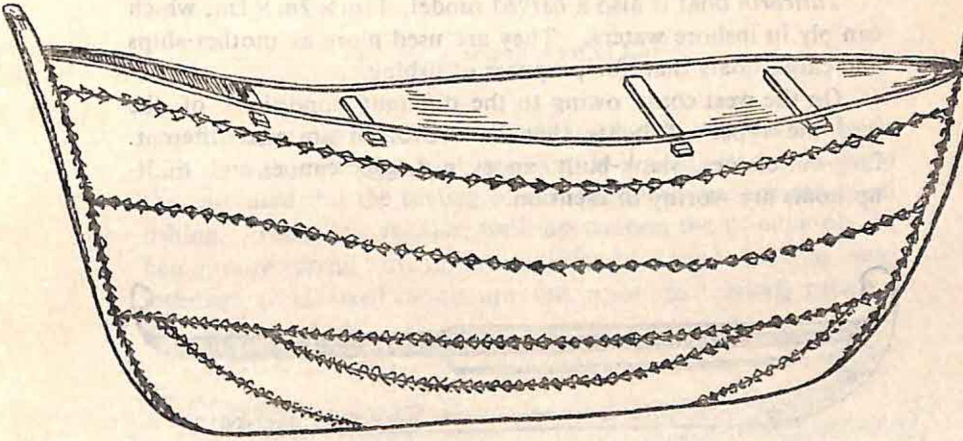

Fig. 21: Padava—a Masula boat of Andhra coast

The *masula* boat is used extensively on the Coromandel coast. It is about 9 metres or less in length. It is constructed with planks sewn together with coir ropes and usually without frames or ribs. There are several variations of this type. In Orissa, it is called *Bar* boat and in Andhra *Padava* or *Padagum.*

Another type with ribs is used in the coastal area between Kakinada and Masulipatnam.

Nauka and *dinghi* are carved boats of Orissa and West Bengal. Naukas are well-designed large boats measuring 13m×3m×2m.

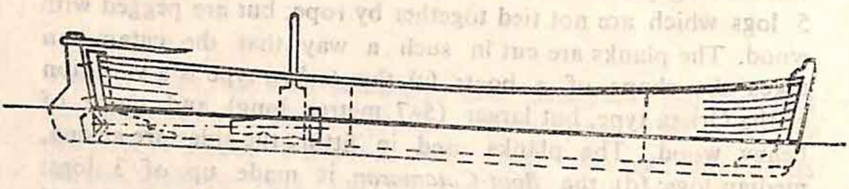

Fig. 22: Tuticorin-type fishing boat (Tamil Nadu State)

Tuticorin boat is also a carved model, 11m×2m×1m, which can ply in inshore waters. They are used more as mother-ships and cargo boats than for purposes of fishing.

On the west coast, owing to the different conditions of the sea, the types of boats that have evolved are also different. Dug-out canoes, plank-built canoes, outrigger canoes and built-up boats are worthy of mention.

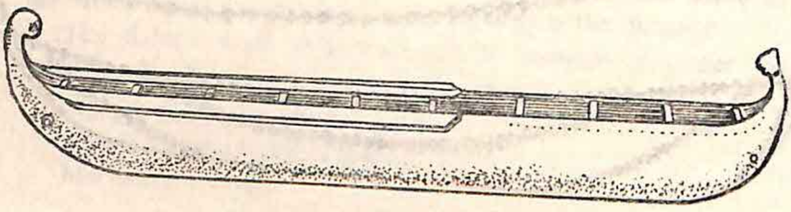

Fig. 23: Odam—A dug-out canoe of Malabar

Dug-out canoes are made from large logs of wood by scooping out the inner part, the bottom or keel portion being thicker than the sides. These are popular on the Kerala and Konkan coasts. The large-sized ones called *Vanchi* or *Odam* are 10–22m long and operate a large variety of nets. The smaller ones, known as *Thonies*, are employed for gill net or drift fishing and for seining. Dug-out canoes are also met with on the west coast between Colachal and Kathiawar.

Plank-built canoes are dug-out canoes which are further enlarged with planks on the sides. They are common in Kerala and are used in boat seine operations. They are also popular in Kathiawar and North Bombay.

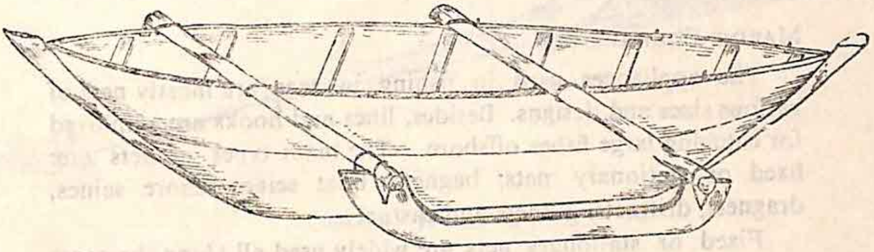

Fig. 24: Rampani boat of Karwar

Outrigger canoes of the Kanara and Konkan coasts are boats with a single outrigger and are locally called *Rampani*, since they are used for the casting of the Rampani net for mackerel fishing. They are regular built-up canoes, the wooden planks being more spread out. The usual size is around 15 × 3m long, although small-sized canoes are also in use, particularly between Bhatkal and Majali.

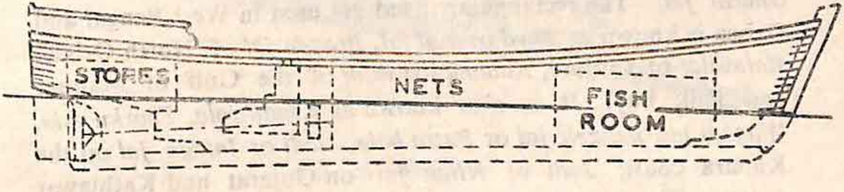

Fig. 25: Fishing Machwa of Saurashtra

Built-up boats are the most highly evolved of indigenous fishing craft. They are operated on the west coast, north of

Ratnagiri and along the Bombay-Cambay coast. There are minor variations from place to place. A *Machwa* with its broad hull, pointed bow and straight keel is very popular in Bassein. A *Satpati* or *Galbati* has a medium pointed bow, broad beam, straight keel and high gunwale. *Satpati* has been found to be an ideal type for mechanization as a motor engine can be fitted without any change in the design of the locally assembled boat.

MARINE FISHING GEAR

The appliances used in fishing in seas are mostly nets of various sizes and designs. Besides, lines and hooks are employed for catching large fishes offshore. The main types of nets are: fixed or stationary nets; bagnets, boat seines, shore seines, dragnets, driftnets, gillnets and castnets.

Fixed or stationary nets are widely used all along the coast from Bengal in the east to the southern peninsula, on to Kanara, Gujarat and Kathiawar. As the name suggests, these nets are fixed in the tidal zones of the inshore waters during low tides. To keep the nets in position, wooden poles called stakes and floats or sinkers are used. Nets are usually rectangular or conical in shape and are of differing sizes. With the high tide, fishes swim into the net and when the water recedes with the low tide, they get trapped. These nets vary from state to state and are called by different local names.

In West Bengal and Orissa the conical fixed nets are called *Panch*, *Kathia-kool jal*, *Panch-kathia-ber jal* and *Behundi* or *Ghurni jal*. The rectangular fixed net used in West Bengal and Orissa is known as *Bayd* or *mal jal*, *Branda jal* of North Orissa, *Kalavalai* of Tanjore, *Kalamkutti valai* of the Gulf of Mannar and Palk Bay. It is also known as *Konda vala*, *Thorku vala*, *Waghol jal*, *Bangela jal* or *Patta bala*, *Jadi* or *Intagh jal* on the Kanara coast; *Jadi* or *Nitah jal* on Gujarat and Kathiawar coasts. These nets are made by hand mostly by fisherfolk themselves in their homes. The small-sized ones are made of cotton yarn, while the larger ones are made of hemp or other strong yarn. They are preserved by treatment with certain local extraction of tree-barks or sometimes by coal tar.

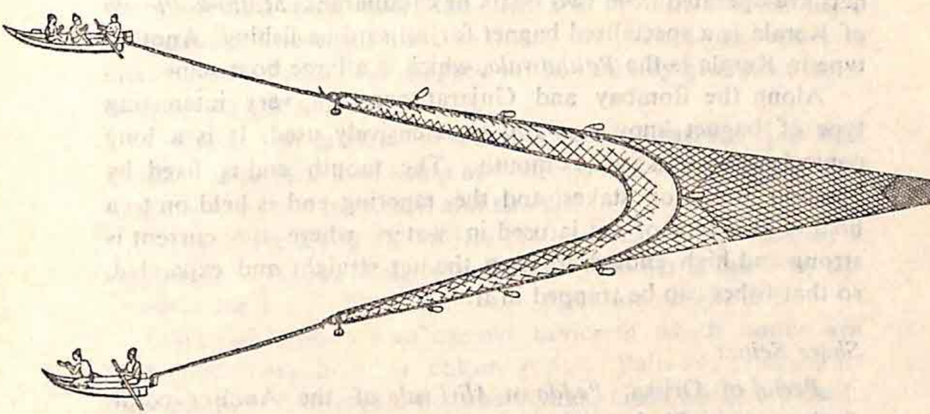

Fig. 26: Thuri Vala

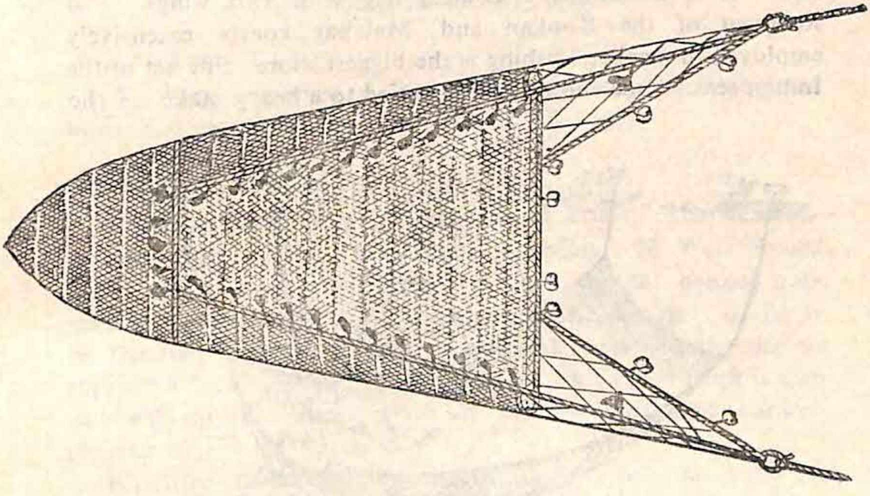

Fig. 27: Kolli Vala

Bagnets are generally conical in shape, without flanks or wings. A variation of this type with long tapering flanks is in vogue. *Iraga valai* of the Andhra coast, *Thuri vala* of Tamil Nadu and *Kolli vala* of Kerala belong to the latter type. These nets are operated from two boats or catamarans. *Mathi-kolli-vala* of Kerala is a specialised bagnet for oil sardine fishing. Another type in Kerala is the *Paithu vala*, which is a large boat seine.

Along the Bombay and Gujarat coasts, a very interesting type of bagnet known as *Dol* is extensively used. It is a long conical net with a wide mouth. The mouth end is fixed by bamboo poles or stakes and the tapering end is held on to a boat. This type of net is used in waters where the current is strong and high enough to keep the net straight and expanded, so that fishes can be trapped in it.

Shore Seines

Berjal of Orissa, *Pedda* or *Alivi vala* of the Andhra coast, *Periya vala* or *Mada valai* of the Coromandel coast and *Kara valai* of the Gulf of Mannar are the commonest examples of this type. It is essentially a conical bag with two wings. The *Rampani* of the Konkan and Malabar coasts extensively employed in mackerel fishing is the biggest shore seine net of the Indian seas. One end of the net is tied to a heavy stake on the

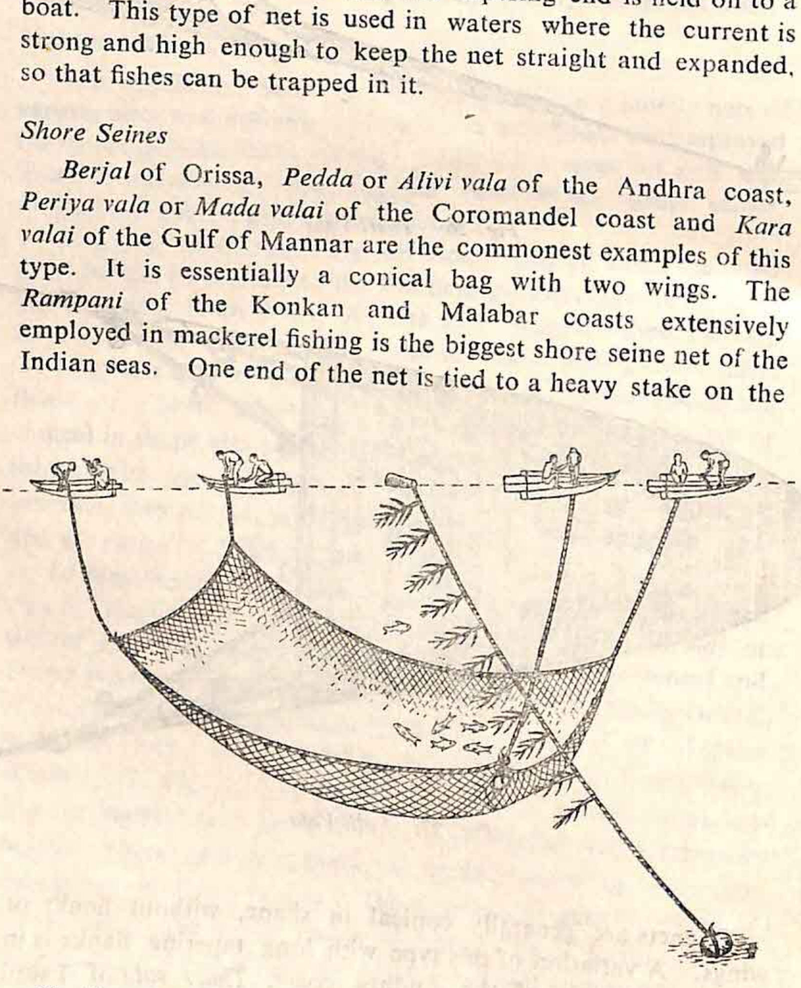

Fig. 28: Mada Valai—A bagnet of Coromandel coast (*after* Hernell).

shore, while a boat takes the other arm into the sea, making a semi-circular sweep and back to the shore. When the net gets filled up with fishes, it is dragged to the shore by groups of men, tugging at each end.

Driftnets and gillnets are wall-like nets of various sizes and meshes. The yarn is of hemp and sinkers and floats are attached to the net to keep it vertical and straight.

Castnets are a popular variety of the small net operated by a single man. It has usually a string. The net is cast by the sweep of the arm. When it spreads, fishes are caught in it.

Lines and hooks are an age-old device in which hooks are suspended from lines or cotton ropes. Baits are attached to these hooks. For large fishes like sharks, chain hooks are used. The lines have to be taken to the sea in boats.

INLAND FISHING CRAFT AND GEAR

INLAND FISHING CRAFT

The craft employed in inland fisheries may be considered under two categories, viz. (i) Rafts and (ii) Boats.

Rafts

Rafts are the most primitive type of boats. They are constructed from various indigenous materials. In West Bengal and some parts of Tamil Nadu, the stems of the banana trees are tied together to form a floating platform. In parts of Bihar on the river Ganges, earthen pots (*chatties*) are tied together to support a light platform of bamboos. This type of raft is also met with in the Kaveri river in Tiruchirapalli and Tanjore districts.

Primitive men invented simple rafts from the hides of animals. In the upper reaches of the Ganges, buffalo skins are tied together to form a crude raft. In the rivers Kaveri and Tungabhadra, fishermen use the coracle, which has a wicker (cane or some other wood) frame-work covered with cowhide.

Dongas of West Bengal are a simple type of a dug-out canoe. It is made by hollowing out the stem of a palmyara palm. It is used in paddy fields and low-lying areas with shallow waters.

Boats

Boats are built from planks and are of various types. They are sturdy and can withstand strong currents and tides in rivers, large lakes and expansive backwaters. One of the well-known types is the *dinghi*, used in West Bengal in conjection with pursenets and dipnets. *Dinghis* have no keels but are narrow and have a tapering bow and stern. When larger nets have to be used, a large-sized *dinghi* has to be employed. Another type is the *Chandi nauka*. It is about 18 m long and 3 m wide and operates driftnets.

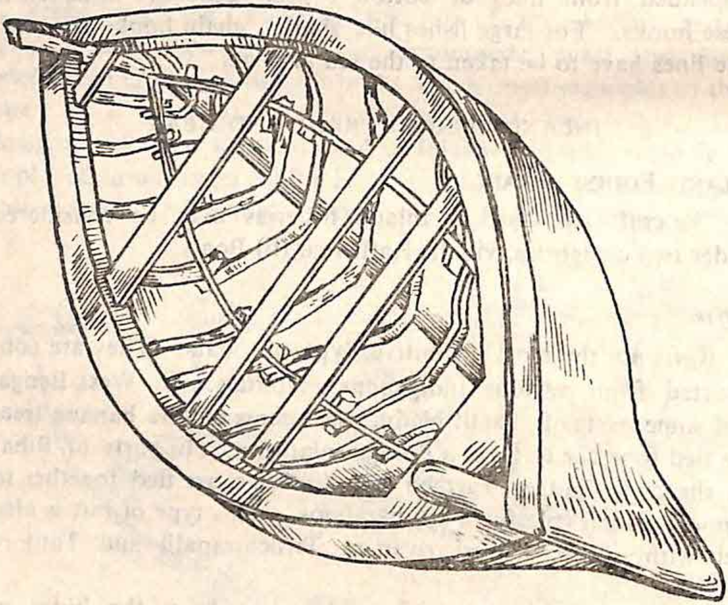

Fig. 29: A carvel built boat of North Orissa

INLAND FISHING GEAR

It has already been seen that India has a wide variety of inland waters. The nets used therefore are naturally very diverse and numerous. Only a few important types will be considered here.

Been Jal is a bagnet set against tidal current. It is tied to stakes or bamboo poles. Floats are tied to the lateral wings. This is operated in deltas of rivers of West Bengal and is used in the capture of small-sized fishes.

Khal Patta Jal of the Sunderbans, *janos* of the Chilka Lake and *thattuvala* of Kerala backwaters are efficient types of gear in estuaries. The principle is to enclose portions of lagoons by means of bamboo screens or other types, so to as draw the fishes into an enclosed area. Fishes are captured by castnets or dipnets or by draining away the water at low tides.

Shanglo Jal is a type of pursenet used in the upper reaches of estuaries. It is operated from a dug-out canoe.

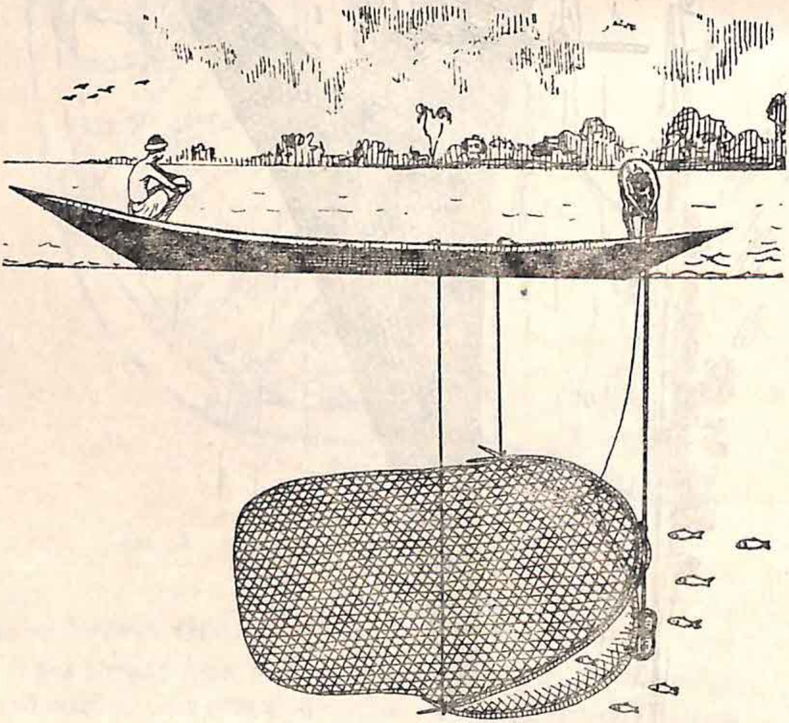

Fig. 31: Shanglo Jal

Chhandi Jal is a drift gillnet in vogue in the estuaries of West Bengal. It is an efficient gear for Hilsa fishing. Each net is 305 m long and 3 m wide, with a mesh of 7.5 to 10.2 cm.

Ber Jal is a large-sized seinenet in the Gangetic waters. It is operated from boats or by wading.

Karal or *Katla Jal* is a driftnet, made of thick cotton, with 13.7—15.2 cm meshes. A series of bamboo floats (about 12) are suspended by means of ropes and operated from a canoe.

MECHANISED CRAFT

From the preceding account, it will be seen that Indian fishermen have been using the age-old craft and gear evolved centuries ago. The first attempt to introduce modern types of boats and nets started around the turn of the century when vessels like the *Investigator* were put out for exploration of the Bay of Bengal. When European countries like Norway, Sweden and Great Britain, the U.S.S.R. and in the east, Japan and the Philippines, were modernizing their fishing industry by the replacement of sailing vessels with motor-driven boats, India, on account of her socio-economic and political situation, did not venture upon any drastically new ideas. It was only around 1950 that the various state governments and private business organisations began to experiment with mechanization, which involves use of boats with motor-engines for sailing and use of mechanical devices for handling fishing gear.

The questions that naturally arise are: Is it advantageous commercially? Is it more economical in the long run? Has India the resources in men and material? Has she got the ancillary aids for mechanised fishing like modern harbours or landing-places, refrigeration plants to store large quantities of fishes and also speedier transport by motor lorry and rail wagon?

The building of new boats with motor-engines to replace the large numbers of indigenous fishing boats is not economical for a developing nation. Instead, installation of motors in the existing Indian boats and converting them into mechanised fleet was tried. Thus the *Machwa* of Saurashtra and the *Dhorow* of Kutch, *Satpati*, *Tuticorin* boats and *Navas* of

Andhra have been found suitable for this purpose. Bombay has a fleet of about 600 motorised boats. Andhra State has designed and built a new model of mechanised boat known as *Nava*. West Bengal has introduced regular motor-vessels from foreign countries.

A further development in the expansion of mechanised fishing is the recent project of the Indian Government which envisages the construction of 40 trawlers in the various shipyards of the country. Of these, 20 trawlers will be assigned to various maritime states and the remaining 20 will be used by the Central Government for its various projects.

The first of these trawlers built by the West Coast Corporation of Shipbuilders of Bombay has been launched. It is 17.5 metres long and is equipped with a Kirloskar marine diesel engine. It will be equipped with a fish-finder, asdic, radio telephone, radar and oceanographic equipment besides all amenities for preservation and storage of fishes.

While modern trawlers are being built with indigenous materials, new fishing-grounds have to be charted, correct methods of fishing evolved and men trained to handle the new craft and gear.

The main fishing stations at present are Bombay, Cochin, Tuticorin and Vishakapatnam. It is proposed to develop additional fishing ports at Kandla, Goa, Madras, Paradeep and Port Blair. Veraval and Mangalore, which were abandoned owing to the shortage of trawlers, will now be restarted.

The older types of nets like the Otter trawl and Beam trawl will be replaced by the purseseine net, used extensively and more effectively for deep-sea fishery in other countries.

It will be seen, therefore, that India is still in the experimental and exploratory stage as far as mechanised fishing is concerned. When the entire project is under way, it is hoped that it will bring in an additional supply of 25,000 tons of catch per year to provide protein-rich food for consumption within the country or even for export.

CHAPTER XI

PRESERVATION AND PROCESSING

EVERY HOUSEWIFE knows that fish decomposes quickly and that it is good only when fresh. In India, with its tropical and subtropical climate, the problem is more acute, as heat and moisture promote deterioration. Fishes when caught and landed may undergo any one of three types of changes, namely, bacterial, enzymatic and oxidative. Bacteria of water and air attack the flesh slowly at first and more rapidly later. Chemical changes cause breakdown of proteins and other nitrogenous matter, leading to the production of substances like hydrogen-sulphate and indol. Marine teleosts usually contain a small percentage of trimethylamine oxide. This compound is reduced to trimethylamine, a basic compound with a characteristic odour of stale or spoiled fish.

As fish is a highly perishable commodity various methods have been devised to preserve it. Before preservation, fishes are washed with clean water to remove slime, blood stains, mud and sand. Larger fishes are gutted (i.e. all the internal organs or viscera are removed) and the body cavity is washed.

The various methods adopted for preservation are drying, salting, smoking, canning and the more modern methods of freezing with ice or in electrical refrigerators.

DRYING

The object of drying is to remove moisture from tissues. This helps to arrest bacterial and enzymatic putrefaction. Sun-drying is the most ancient of methods. In India over 35% of the total catch of sea fish is cured in the sun.

Small marine fishes, such as ribbon fish, silverbellies and Bombay ducks, are spread on the open sandy beach. Sometimes mats made of coir or palm leaves are used for spreading the fish upon. Often, fishes like Bombay ducks are hung on bamboo or wooden rods or on ropes stretched horizontally between poles. Large and medium-sized fishes are generally gutted and salted before drying.

Sun-drying is not the ideal way of preservation. It has certain disadvantages. It is not hygienic. Further there is an appreciable percentage of loss through putrefaction and spoilage and the dried fish develops a peculiar odour. The recent trend is to use mechanical driers. This process yields a high quality product which retains the natural flavour and nutritive values.

SALTING

Salting is a form of pickling and is widely used in India, not only for fishes but also for all kinds of vegetables and fruits as well. Common salt acts as a preservative by preventing bacterial growth and by inactivating enzymes. Two methods of salting have been evolved in India for fishes. They are dry-salting and wet-or brine-salting.

Dry-salting

Fishes are first rubbed with salt powder and then packed in tubs or in cemented tanks. Dry salt powder is sprinkled in between layers, as the fishes are arranged in the container. The ratio of salt to fish varies from 1 : 3 to 1 : 8 depending on local practice, weather conditions and type of fish. It is found that oily fishes require more salt. After a period of about 10–20 hours, the fishes are removed from the tubs and tanks washed in their own brine (salt water) and dried in the sun for 2–3 days.

Wet-salting

Wet-salting is mostly practised on the Konkan coast. Cleaned fishes are packed in large vats containing a concentrated salt solution and stirred daily till properly pickled. Large-sized fishes like the Indian salmon, seerfishes and black pomfrets are gutted first and their insides cleaned. Also longitudinal slits are made in the flesh to allow penetration of salt. Salt in the proportion of 1 : 3 is applied in three successive stages. On the first day, half of the salt is rubbed into the incisions and the fish is stored on the cemented floor of the curing-yard. On the second day, the fish is shuffled, so as to bring the bottom layer on top and half of the remaining salt is rubbed and the fishes are restacked. The stock is left undisturbed for 7 to 10 days. The salty water that oozes out from the fish is allowed to drain off. Wet-salted fish is sold without drying. It does not keep good for long and therefore has to be used within 3 to 4 months.

SMOKING

Smoked fish is not as popular in India as it is in Western countries like Norway and Sweden because the peculiar smoky flavour is not relished by Indian fish-eaters. However, small quantities of surplus fish are smoked in Madras and Orissa. Sardines, mackerels, seerfish, pomfret, jew fish and hilsa are considered good varieties for smoking.

Fishes are first cleaned and gutted and then soaked into salt or brine. They are taken out from the salt solution and are suspended on rods in a kiln or smoke-house. Smoke has a preservative effect, which is ascribed to its phenolic constituents.

CANNING

Canning is a process evolved in Europe and now introduced into other countries. It retains the natural flavour of the fish. Whenever available in large quantities, sardines and mackerels are canned on the west coast of India like Calicut, Goa and Bombay. The industry has not been successful due to various adverse circumstances in India, such as irregular supplies of fish, shortness of canning periods and paucity of good and cheap material, such as tin, for containers.

Pasting, *pickling* and *spicing* are indigenous methods of the East.

Pasting is mostly done in homes in the Malabar coastal areas. The fishes are cut into slices, salted and dried, They are then mixed with a spicy paste ground by mixing vinegar, red chillies, mustard, garlic, turmeric and tamarind in a medium of oil.

For pickling, usually mackerel and sardines are used. These fishes are gutted, washed and salted. A souring and preserving agent, the dried pods of the fruit, 'kodakka puli' *(Garcinia* *cambogia* (Desr) indigenous to Malabar) are packed into the abdomen of fishes. The processed fishes are arranged in wooden barrels with additional salt and fruit pods. If the above special fruit is not available, tamarind may be used.

REFRIGERATION

The most recent method of preservation is refrigeration and freezing as these prevent putrefaction and decay. Frozen fishes retain their nutritive qualities for a long time, perhaps even for a year. Fishes are packed in ice for short-time preservation in markets or for transport. For long-time preservation, large electric refrigerators or deep-freeze cabinets are employed. In big commercial concerns like those in the Sassoon Docks in Bombay, rooms are cooled by electric refrigerating methods and large quantities of fishes are stored in them for months. Quick freezing is advised where fishes have to be kept for a longer period. The carrier air-plast type of quick freezing is employed at Bombay, Mangalore, Calicut, Cochin and Trivandrum.

Cold storage preservation of fish is not yet widespread in India. In the large cities where fisheries are highly developed, limited cold storage facilities are available. Here fishes are kept overnight by dealers before marketing the following day.

COMPOSITION AND USES

The flesh of fishes contains organic and inorganic compounds. They are (a) water 80%, (b) protein 15–25%, (c) mineral matter 1–2%, and (d) other constituents 1%.

Proteins are found in the muscles and contribute the most important item of food to man. They are easily digested and are superior to other animal proteins like egg albumen, beef and casein of milk. In fact, they are equal to chicken protein. The mineral content is made up of calcium, phosphorus, sodium, potassium, sulphur and chlorine—all in small quantities. Iron, calcium and phosphorus are also present in readily available forms, particularly in the bones.

Fishes are noted for their vitamin content. The important vitamins are A, C, D and B-Complex of the thiamine, riboflavin and nicotinic acid groups. The livers of several species are very rich in Vitamins A and D. Fish eggs (roes) and fish liver are very good sources of B-Complex and also Vitamin C.

BY-PRODUCTS AND OTHER USES

Besides providing food to man, fishes are a source of numerous by-products of which oils are the most important. Fish oils are of two kinds: (1) liver oil (2) body oil.

LIVER OIL

Fish liver oil is considered important because it is one of the natural sources of Vitamin A and, to a lesser extent, of Vitamins D and C. Fishes like cods, halibuts, tunas, sharks and rays are the best yielders. The relative values of oil content and vitamins may vary from group to group.

Before World War II, Norway and Sweden were the leading countries in the fish liver oil trade. They extracted and exported large quantities of oil from cods and halibuts occurring in great shoals in the North Sea. During the turbulent days of World War II and the dislocation of shipping and sea services, the supply of liver oil was cut off. The Indian Government and scientists immediately began a search for resources from amongst indigenous fishes. As a result, it has been found that Indian sharks and rays are an invaluable source of liver oil, both as regards quantity and quality.

Vitamin A exists as fatty acid esters and in two forms, namely, Vitamin A_1 and Vitamin A_2, the latter being 40% as active as A_1. Among those rich in Vitamin D content, the tuna, the halibut and the cod may be mentioned. Vitamin D content is independent of Vitamin A. Vitamin E is also a constituent part of fish liver oil. Vitamin A is essential for proper vision and Vitamin D for healthy bones. Both these are very important for the growth of infants and childern, especially in India where malnutrition prevails. These vitamins are also essential to poultry and livestock whose feed may be fortified by fish oil.

Liver oil is extracted by several methods. Liver lobes are removed from captured fishes and are immediately preserved in common salt or in weak formalin (formaldehyde diluted with water). A more recent method is to freeze the liver and to store it in a refrigerator. Stale and diseased livers are not used. It is very essential that good and healthy livers should be selected for medicinal extracts. The extraction may be done by one of the four well-known methods:

(i) *Steaming*

The livers are minced (cut into small pieces) and cooked in tanks at 85–90°C. When the tissues disintegrate and the oil comes up to the surface, it is skimmed off and collected in vessels. This method is applicable to fishes such as cods and oil sardines which have a high oil content.

(ii) *Floatation*

Fresh liver lobes are preserved with a chemical substance called Aquacide (a mixture of paraldehyde and sodium bicarbonate) for a few days during which time, the protein matter of the liver is denatured, yielding a pulp mixed with a fluid. The pulp is separated and passed through a series of tanks or cylinders into which hot water is piped. This extracts the oil which floats to the top. This method has been found successful in the cod liver oil industry in the West.

(iii) *Alkali-Enzyme Method*

The liver is ground and treated with caustic soda (1-2% by weight) or with sodium carbonate (2-5% by weight) with constant stirring for about an hour. The pulp is subsequently passed through a centrifugal (high revolving) machine when the oil separates.

(iv) A variation of the above method is to add hydrochloric acid and pepsin (chemical preparation 0.5% by weight of liver) to minced liver mixed with an equal quantity of water. The temperature is maintained at 43-49°C and the pH adjusted to 1.2–1.5, when extraction starts. Later the pH is raised to 9.0 by the addition of sodium carbonate. The temperature is slowly raised to 80°C and the steaming is continued for another hour, when the oil rises to the surface. The oil is collected, filtered and stored.

The crude oil extracted by any one of the above methods is first allowed to stand for some days. When water and particles of liver tissues settle down, the clear oil is separated. If the oil is required for medicinal purposes, it has to be treated further by filtration, centrifuging or treating it with Fuller's earth. The resultant oil contains stearin, which forms a sediment when stored at low temperatures (0–10°C). The pure oil is filtered in a cold room.

Shark Liver Oil Industry in India

The sharks that are important in the liver oil industry are *Galeocerdo tigrinus*, *Carcharhinus melanopterus*, *C. gangeticus*, *C. limbatus*, *C. menisorrah*, *Syphrna blochi*, *Scoliodon palasorrah*, *S. walbeehmi* and from amongst the rays, *Pristis cuspidatus* and *Pristis microdon*.

The production and marketing of shark liver oil are carried on in Kerala, Bombay and Madras by the fisheries departments of the respective states. The crude oil is refined, diluted with deodourized groundnut oil to the required Vitamin A potency and enriched with synthetic Vitamin D. The annual production is about 70,000 gallons. The oil finds markets within the country, as shark liver oil is not exported. Shark liver oil is known by different trade names, such as Sharko-Vit, Elasmin liquid, Elasmin pearl MGB, Stayfit, Adamin, etc.

BODY OIL

Fishes with fat or oil, such as sardines, herrings and salmon are the most suitable for the extraction of oil. Body oils are prepared side by side with the manufacture of fish-meal. Fishes are crushed in order to make a pulp and then cooked with steam. The cooked flesh is pressed and oil and 'stick water' (i.e. press liquor) mixture are drawn into settling tanks or passed through centrifugals to separate the oil. The residue, dried and powdered, is known as fish-meal.

Body oil is also extracted from 'filet waste' (all the left-overs like tails, fins, bones when fishes are cut and cleaned in fish markets). Also whole sharks, after liver is removed, are used. The material is ground and cooked under continuous stirring in a cylinder heated from outside by steam. The oil when separated is pressed out. With the growth of chemical technology, more modern methods are being tried for more efficient extraction. For refining oil, the hydrogenation method is employed. Mackerels and oil sardines are the chief sources of the body oil industry which flourishes mainly on the Malabar coast.

Fish oil is used extensively for the manufacture of edible oil, margarine, lard-substitutes, soap, paints and varnishes.

OTHER FISH BY-PRODUCTS

There are numerous by-products, besides oil, which are economically useful. The most important are fish-meal, fish flour, fish proteins, fish glue, isinglass and fish skin.

Fish-meal

Fish-meal is prepared from the waste collected from fish markets or from factories concerned with oil extraction and canning or from surplus fish during periods of glut or abundance. Fish-meal, on an average, is composed of 55–70% proteins, 2–15% fat, 10–12% minerals, and 6–12% water, besides small quantities of iron, calcium and phosphorus and traces of Vitamins A, D, B and K. It is, therefore, a valuable source of food materials.

Fish-meal may be prepared by any of the processes described above for the extraction of oil. The meal is dried either in the sun or in flame driers, or more commonly in steam-jacketed drums, under partial vacuum, which yields a superior quality of the product.

High quality fish-meal is used on animal farms to supplement the daily diet, while the low-grade variety is used as manure in plantations of coffee, tea and tobacco. It is estimated that India produces each year 1.5 lakh maunds of fish-meal. The important area of production is between Karwar and Cape Comorin on the west coast.

Fish Flour

Fish flour is the fine, superior quality of fish-meal, which is good for human consumption. It is prepared on a commercial scale by the solvent extraction method. The principal use is as supplement to protein diet. It can be blended with wheat or maize flour. It is used as an enriching component in bread, biscuits, cakes, sweets, soups and gruels. The proportion recommended is about 10% only.

Fish Proteins

Proteins in their purest form are extracted after fat is eliminated from fish-meal, with a dilute caustic soda solution. The resulting product is neutralised and is dried by spraying. The fine powder thus obtained is white in colour, contains 80-90% of soluble proteins and is free from fish odour. Refined fish protein can be used as a substitute for the white (albumen) of egg in baking cakes, etc. and in ice-creams. It is also a valubale ingredient in certain pharmaceutical products.

Fish Glue

Fish glue is prepared from skins, fin-trimmings and bones. The raw material is first washed, ground and cooked in steam-jacketed vessels for 6–10 hours with a small quantity of acetic acid. The liquid is then separated and concentrated. Fish glue is used as an adhesive in book-binding, backing for lables, for paper-boxes and in furniture-making.

Isinglass

Isinglass is a high-grade collagen produced from the air-bladders of certain groups of fishes, particularly those of catfishes, perches, sciaenids and polynemids. The bladders are washed to remove blood, etc. and the outermost layer or coat is scraped off. The inner layer is dried and marketed as isinglass, which is used in the clarification of wines, beer and vinegar. It is also used in the preparation of plasters and special cements.

Fish Skin

The skin of the larger varieties of fish such as sharks and rays are tanned and marketed as ornamental leather. The method of curing of the skin as followed in foreign countries is as follows: the skin is detached from the muscles and soaked into brine for a day, after which it is removed and all the salt solution drained off. It is again salted and soaked into a fresh salt solution containing 10% hydrochloric acid. It is once again drained and all the scales or denticles on the skin scraped off. Subsequently, it is coated with lime and tanned like any other leather.

Tanned fish skin is used in the manufacture of shoes, hand-bags, wallets and tobacco pouches and trinket or ornament boxes. Shark leather has a peculiar grain besides being soft and pliable, which qualities enhance the utility and beauty of the various articles made from it.

CHAPTER XII

FISHERIES TODAY—GROWTH, EXPANSION AND TRADE

HISTORICAL

TILL THE end of World War II, around 1945, India was carrying on with age-old practices of fishing with indigenous boats and crafts in the limited shore areas of the coastline. Most of the catches were sold locally. A small portion was dried or salted and exported to neighbouring countries. Fisher-folks lived barely at subsistence level.

As already noted, from 1946 surveys of offshore waters started. A pilot deep-sea fishery station at Bombay followed by some states bordering the coastline explored the seas to locate new fishing grounds. These investigations yielded larger catches and the trade began to improve slowly. Around 1950, India experimented with freezing and canning surplus fish which was exported to foreign countries—the beginning of international fish trade.

During the last 35 years, there has been steady growth and expansion in India to claim an important position in the world fish trade. Most of the marine fishes, described in the section of the common fishes of India (Chapter VIII), contribute in large quantities to the fishery operations. Besides, there are two other groups of marine animals, which add to our resources. Firstly, there are the crabs, lobsters, prawns and shrimps belonging to the Crustacean class of the invertebrate sub-kingdom Arthropoda. It is interesting to note that prawns and shrimps top the list in quantity (tonnage) and in foreign exchange earning in the export market. The second group includes clams, mussels, squids, cuttlefishes, etc. of the sub-kingdom Mollusca. These two groups are not fishes in the Zoological classification, but in statements and accounts of marine products and their exports, they are listed along with fishes for convenience.

EXPERIMENTAL STAGE

In a vast country like India how are the various aspects of its fishery resources managed? A survey of our fishing crafts and gears (Chapter XI) reveals a picture of the early history. From the 'Catamaran' of Tamil Nadu—a primitive raft—to built-up boats like the 'Machwa' of Saurashtra are locally constructed wooden boats without sails or rudder and are the types of crafts used by our ingeneous fishermen. The nets used are simple devices made of strings of cotton, coir or other plant-fibres locally available. Both boats and nets have their limitations in catches as well as the distances and depths covered in the seas.

The period starting with 1950 saw the beginning of the experimental stage in modernization of fishing industry in India—the introduction of mechanized boats, trawlers; more efficient nets like purse-seine; and chartering of new fishing grounds in the Arabian Sea, Bay of Bengal and the Indian Ocean. Expedition of 1970 gave a rough estimate of fishes and other sea-foods as 12-15 million tonnes which many fishery biologists believed as under-estimated. To exploit more the rich resources of the seas, a ten-year survey (1971-80) was undertaken by the Fishery Survey of India at the initiation of the Central Government. It started with the Gulf of Mannar, on the southern tip of the continent, off Tuticorin. The information collected was passed on to the fishing trade.

The growth in population and demand for more fish compelled a more thorough and systematic survey in the early seventies. A fleet of trawlers 17.5 meters long was deployed. They began sampling fishing grounds upto a depth of 75 meters in the Gulf of Mannar. *Meena Saudagar* and *Meena Niryantak* are trawlers worthy of mention is this historical task. The target of the Fishery Survey was to cover the entire coast of India as it launched in 1972 *Matsya Nireekshani* which is not only the largest but most sophisticated trawler of modern India. It is equipped with echo-sounder, sonar scanner and electronic length-frequency analyser. It has a capacity to cover upto 500 metres deep in the sea. It has gathered information on various fishing grounds and also on varieties of fishes living in deeps. The knowledge gained is communicated to industrialists who use trawlers. Thus a new impetus has been imparted to our fisheries.

From 1972-83, the Indian Sea-Food Industry emerged out successfully, ranking as the 7th largest country in the world. According to a recent review the annual quantity harvested from our seas is 92,000 tonnes, earning about 373 crore rupees in foreign exchange.

PRESENT STATUS

According to recent survey (1983-84). India has over 20,000 mechanised vessels, 1,40,000 traditional crafts, with facilities to land in 1,800 centres along its long coast. These facilities include harbour, landing, berthing and out-fitting facilities, repair houses for boats, proper electricity and water supply, ice plants for refrigeration of fishes and even roads to connect to the nearest town and railway station. The Indian Fisheries now employ 4 million employees who include fishermen and their families, technologists, processors, scientists, fishery biologist and exporters.

The chief countries to which India exports its fishes and other sea foods are—Australia, Belgium, Canada, Federal Republic of Germany, France, Hong Kong, Italy, Japan, Kuwait, Mauritius, Netherlands, Singapore, U.S.A., U.K. Yugoslavia, Zambia, Sri Lanka, United Arab Emirates. The major markets, however, are Japan, U.S.A., and West Europe.

All the maritime states in India are engaged in the fishing trade as seen from the lists of important ports which engage in exports; Porbunder, Veraval *(Gujarat)*, Bombay, Ratnagiri *(Maharashtra)*; Goa, Mangalore *(Karnataka)*; Calicut, Cochin *(Kerala)*; Tuticorin, Nagapattanam, Cuddalore, Madras *(Tamil Nadu)*; Kakinada, Vizag *(Andhra Pradesh)*; Calcutta, Paradeep *(West Bengal)*; and lastly Port Blair *(Andamans)*.

With the expansion of fisheries markets, increase in production and export, the Government of India was faced with problems of resources and their quality, marketing technology, fish and fisheries education and research, the overall control of sea food industry etc. The organizations and institutions, that the Government has established to regulate and guide the several aspects of fishery industry and allied concerns, are varied as seen in the list below:

a) Central Marine Fisheries Research Institute *(Cochin, Kerala State)* undertakes research in all aspects of marine fishes and fisheries.

b) Inland Fisheries Research Institute *(Barrackpore, West Bengal)* deals with research on riverine, estuarine, lacustrine (lakes) fishes and their fisheries.

c) Indian Institute of Fisheries Technology, (*Cochin, Kerala State*) doing research on ideal crafts and post-harvest technology.

d) Institute of Nautical Engineering and Training, *(Cochin, Kerala State)* trains personnel for operating fishing crafts and gears.

e) Integrated Fisheries Project of India *(Bombay, Maharashtra State)* concentrates on fishes, their biology, exploration of fishing grounds.

f) Institute of Fisheries Education (*Bombay, Maharashtra State)* is designed for teaching and research, both theory and practice on all aspects of fisheries, resources, fishing grounds, crafts and gears, modernization of boats, trawlers and equipment.

g) Marine Products Export Development Authority *(Cochin, Kerala State)* is the national organization responsible for the overall developments, regulation and controls of sea food industry as related to export.

h) Export Inspection Agency *(Cochin, Kerala State)* to maintain quality, hygiene, sanitation level of products and inspection of processing plants and package products at export points.

i) Fishery Survey of India (Exploratory Fisheries Project) Bombay, (*Maharashtra State)* to provide training and vital information required for a systematic exploitation of the Indian Seas.

Besides, the above organizations, study of fishes and fisheries biology has been introduced in colleges and universities in several states of India both in graduate and post-graduate courses. Also, research on classification, anatomy, physiology, embryology, endocrinology etc. of fishes as well as fisheries, both inland and marine, hydrology, water pollution etc. is undertaken by scholars at doctorate level.

Mention must be made on the contribution made by the Zoological Survey of India which maintains reference and type collection of the various species of Indian fish fauna in the Indian Museum at Calcutta and also carries on research on the classification and distribution of fishes from the mountain streams of the Himalayas to the depths of the seas.

In the preceding pages the challenge of her seas by India, is seen in the rapid progress of her fisheries industry. Within the last four decades, the industry has reached a top position in exports. In the world sea-food trade, India stands first in prawns and shrimp export tonnage and second largest in marine fisheries among developing nations, while seventh in the world. Over sixty countries now depend on India for sea-food supply abounding in the comparatively clean and pollution-free waters, stretching over 200,000 square kilometres of her sea-bed.

Further, the seas have opened up employment for millions of people. Most of all, thousands of fishermen and their families have benefited from fishing industry; their earnings have grown and their socio-economic conditions have improved. Their welfare is an important feature of the various concerned organisations. Each of these organisations is managed by competent and trained professionals, who direct the complex, multi-faced industry towards greater productivity and excellence.

CHAPTER XIII

MAN-EATERS OR KILLERS OF THE SEA

In a previous section, a brief account of the important sharks and rays that inhabit the Indian Seas has been given. Fishermen, sailors and bathers think of these creatures in general as harmful predators, which attack humans who venture to trespass into their realm, even tearing up limbs and flesh, causing death. The menace that a shark can inflict is cleverly brought up in his book by Peter Banchley *Jaws*, which later has been produced into a famous motion picture of the same title.

Sharks and rays are carnivorous by nature predating on fishes, molluses (shell fishes), crabs, prawns, etc. The most dreaded, the so-called *Maneaters* or *Killers of the sea* or sometimes as *Savages* belong to about two dozen kinds of sharks reported or observed, out of about 250–300 different genera that inhabit the oceans around the world. Here only five best known sharks shall be dealt with. These are – Hammer-Head Shark, Great Blue Shark, Great White Shark, Tiger Shark and Mako Shark.

Hammer-head Shark (*Sphyrnbbohi cuvier)*

The Hammer-head Shark is about 3.6–4.5 m long. In colour, it is brownish grey in general, with a touch of olive green above, which grows paler towards the ventral side. The pectoral fins are small, first dorsal fin large and tail fin very large and prominent. With the head drawn out sideways like a hammer, the fish looks bizarre and formidable. It is very agile and quick in its movements. It is considered as the liveliest of shark and therefore an excellent sport fish. It is voracious and feeds on crustaceans, mussels and even sting rays. Its liver-oil is rich in

Vitamin-A. It travels in schools and occurs in Indian and Atlantic Oceans.

GREAT BLUE SHARK (*Prionce glauca* Linn)

Great Blue Shark grows to 3–3.6 m or more. It is a strikingly beautiful fish with its brilliant colour, side being bright blue and snow-white below. Its body is thin and slender with long pectoral fins. It enjoys wide distribution, found in all temperate, tropical and sub-tropical seas, preferring the open waters and moves in large numbers. It is known for its prolific breeding, 28–54 young ones are born at each gestation. It belongs to the family of Carcharhinidae.

GREAT WHITE SHARK (*Carcharodon carcharias* Linn)

Great White Shark is one of the large-sized sharks, the largest recorded is about 11.2 m long, although the average ones are 3.6 to 3.9 m only. In colour, it is seldom white, but slate brown or lead grey in general, with the dorsal surface almost black, while the ventral side is dirty white below. Its body is stout, head short with pointed snout. There is a distinguishing black spot at the base of each pectoral fin. Gill slits are prominently long. It is fierce, quick, voracious, aggressive and over powering and is known to attack with or without provocation. It is solitary by habit and referred as 'Lone Wolf'. It is world wide in distribution in tropical and temperate waters. It prefers offshore pelagic seas, but sometimes comes close in-shore. White Shark is always on the prowl in search of food, which consists of porpoises, seals, salmon, other sharks and turtles.

TIGER SHARK (*Galeocerdo cuvier* Leseur)

As the name suggests, these sharks are striped like a tiger. In the young specimens the skin presents dark spots. As the fish grows older, the spots fuse into broad stripes. These markings fade with age. The adults are grey or greyish brown above, growing paler below. It grows in size to 3.6 to 4.2 m long, sometimes even upto 30 m. It has a short, blunt snout and slender body, tail being characteristically long with a sweeping upper lobe.

The fish is found in large numbers in South Africa, Philippines, Indo-Pacific oceans, West India, Caribbean and Australia. It moves in schools and is considered one of the most dreaded sharks, with record of attacks and killings of humans, especially to sea bathers. It is noted for its prolific breeding, the female gives birth to about 30–60 offsprings, In each breeding season.

MAKO SHARK (*Isurus Oxyrinchus* Rafinesque)

The most outstanding feature of Mako Shark is its brilliant cobalt blue colour on the dorsal side, while snow-white on the under side. The shark is slim, with a pointed snout, evenly sized tail lobes and long gill slits. It grows to a size of 1.8–3.6 m or sometimes more. It is recorded from both temperate and warm waters of the Pacific, the Indian and the Atlantic oceans and also in the Mediterranean Sea.

The shark is aggressive and moves with quick strokes, and by nature it is a fearless fighter. Mako is the largest North American game fish, a favourite of sportsmen. The noted writer Earnest Hemingway (author of *The Old Man and the Sea)* held the record for the heaviest Atlantic Mako ever hooked by rod and reel (768 pounds).

Mako is also popularly known as Blue Pointer, Sharp-nosed Shark, Bonito Shark and Mackerel Shark.

Measures of defence against Shark attack

From very early days man has been searching for ways and means to protect himself from shark attacks. Island dwellers, fishermen, bathers, travellers in boats and ships etc. have been victims of shark bites. These fishes attacks boats and ships by their heavy and powerful body and tailfins. In tropical countries, the inhabitants have tried to ward off sharks by applying on their bodies extracts of herbs, berries, perfurmes, different kinds of oils and chemicals. Sharks are highly sensitive to smell and it is estimated that they can detect the smell of human blood in one part of blood in 10 million parts of water.

One of the modern methods is the use of fencing the infested area, where people resort to seaside for bathing or boating. In South Africa (Durban) and Australia (Sydney), long fences, similar to fish nets or wire mesh have been tied around the enclosed area where sharks infest. This is considered fairly effective but the construction and upkeep are very costly. Another method is to create a wall of bubbles. Compressed air is pumped through perforated pipes to build up a fence of bubbles. But this has not been found very practical.

During World War II countless thousands of ships, aeroplanes and submarines had been attacked and destroyed by enemy, either by bombs, mines and torpedoes. Soldiers, sailors and airmen fell into the seas and became a prey to ferocious sharks prowling in the waters. To find effective repellant was an urgent need.

In nature, animals like octopus, Cuttle fish and their allies secrete an ink-like fluid from a special body-pouch and create a smoky cloud around them and camouflage themselves. In like manner, scientists began to search for suitable chemicals to act as camouflage. Ammonium sulphate dissolved in sea water is somewhat effective, while copper acetate has been found most useful. Copper acetate is formed by precipitation of acetic acid with copper sulphate. If this compound is mixed with a colouring substance (dye), it would be a more practical repellant. Scientists hit upon Nigrosine dye and mixed it with copper acetate in the proportion of 4 parts Nigrosine and 1 part of copper acetate and packed the mixture like soap-cakes and gave the trade name 'Shark Chaser'. Those combat men going in and around seas, were required to keep a cake as part of their outfit.

The menace of sharks still keeps on. In the United States of America, therefore, the Shark Research Panel was founded in 1958 which is attached to the American Institute of Biological Sciences. The aims of the panel are threefold— (i) to study the kinds of sharks, their habits, behaviour and functions;

(ii) to keep an up-to-date record of shark attacks; and (iii) to make investigations on the methods and results of repellants.

To sum up, the final verdict, according to Coasteau*, the French explorer and naturalist, "it is impossible to guess how a shark will react, the more one sees of them the less one knows them, and one must mistrust them more and more".

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*Jacques and Coasteau, P, *The Sharks, the Splendid Savage of the Sea,* Cassell, London 1974.

CHAPTER XIV

HOME AQUARIA

NEXT TO birds, fishes are pehaps the most colourful of animals. They are graceful in their shape, body-form and movement. It is believed that it is the Chinese who first conceived the idea of growing them in and around the homes, just like plants and flowers to add beauty and charm. Thus, varieties of goldfishes which are popular with aquarium-lovers were bred by them from ordinary carp-like fishes. Goldfishes are nothing but varieties of the genus *Carassius*, a fresh water group of fishes related to the carps.

Keeping of home aquaria has now become a very popular pastime all over the world. It is a hobby which appeals to young and old and has opened up a flourishing business in all big cities. There are also societies of aquarists, who meet not only to exchange ideas, but also rear fishes, very much like philatelists.

An aquarium can be a simple glass bowl with a goldfish set on a drawing-room table or it can be a regular, conventional glass-house in a metal frame. It can be a large tank on a verandah or in the foyer of large offices or public buildings. The number of fishes may vary from a single goldfish to several or even hundreds, according to the size of the tank as well as the size of the fishes.

Aquaria can be bought readymade always. If one is careful, the making of the tank and procuring of the fishes need not be an expensive item. Raw materials like glass and aquarium cement may be bought and assembled. Small fishes can be collected from little ponds and streams. More fanciful varieties can be bought from the market for a few rupees.

The idea of an aquarium is to provide for pet fishes a home as near as their natural one. To achieve this, certain simple basic principles have to be followed. They are (a) physico-chemical conditions, (b) biotic, (c) feeding, cleanliness and hazards.

Of the physico-chemical conditions, the prime requirements for a living organism is oxygen. It is, therefore, important that an adequate supply of oxgen is ensured in the aquarium, as fishes can only breathe the dissolved oxygen in water. The minimum requirement is 50-75 sq cm of surface per 6 sq cm of fish and 152-254 mm in depth of water. Overcrowding should be avoided at all costs. Light is the second factor. Only moderate light is necessary, preferably north light, and glare has to be cut off. Light is essential also for the plants in the aquarium for their photosynthesis, during which process they take in carbon dioxide from the air and give out oxygen. Temperature is also important in the maintenance of an aquarium. About 75°F is found to be the optimum temperature. In cold places or in severe winter, it is advisable to keep a lighted electric bulb to give sufficient heat.

Fishes canot live in isolation in an aquarium. They thrive best in the company of other animals and plants which go to form the requisite biotic conditions.

In natural conditions, fishes coexist with a large variety of aquatic animals. In an aquarium, small animals have to be introduced carefully. Crustacean water fleas like *Daphinia* and *Cyclops* and shrimps are desirable as they provide natural and nutritious food to aquarium fishes. Small water-snails are recommended as they feed on the algae which tend to grow on the side of the glass and thus act as scavengers.

Plants are an important feature of an aquarium. Through their peculiar chemical ability called photosynthesis, the plants convert CO_2 exhaled by fishes into food for themselves and, in turn, liberate oxygen during daytime. During the night both plants and animals respire, thus using up oxygen. Therefore, overcrowding of plants has to be avoided to ensure an adequate supply of oxygen to fishes. Roughly one plant for every 26-52 sq cm of the bottom area of the aquarium tank will be sufficient. These plants should be aquatic herbs like *Elodea* or *Chara* or small water-lily or those which are naturally found in fresh water ponds or streams.

Precautions have to be taken against certain natural hazards. Dangerous insects and their larvae should be avoided, as they may predate on the fishes. Tiny coelenterate animals like *hydra* are also not desirable, as they are voracious feeders and consume water fleas which provide food to fishes. Parasites and germs are also to be excluded as they lead to skin infections.

HOW TO PREPARE AND SET UP THE TANK

Having decided to select the correct size of the tank that is required, the first step is to collect the sand that is necessary to make the bed at the bottom of the tank. The sand can be collected from the sea-shore or a river. In places like Bombay and Madras, shops which deal with aquarium equipment stock varieties of sand. The sand has to be washed till all the dirt disappears and it is thoroughly clean. It is advisable to put the sand in a shallow pan or aluminium vessel and heat it. In India, the cleaned sand may be spread in the bright sun. Either of these processes ensures the killing of all bacteria or germs. When the sand is cooled, put it on the bottom of the aquarium and spread it evenly till it reaches a height of 76 mm. While these preparations are going on, water plants which are needed may be collected from a pond or stream, washed thoroughly and kept in a bowl of water.

The tank should be kept on a stand or table at a convenient spot, which has just enough light. It is should now be filled by water to about three-quarters of its capacity. It is advisable to use rain water, which is free from chemicals. If this is not available, tap-water, which has been stored for several days, may be used (storing is necessary to remove chlorine). The plants may now be introduced into the aquarium and fixed at intervals in the sand. Also some of the small animals like shrimps, snails and water fleas my also be added.

To obtain the maximum benefit, the temperature should be maintained uniformly at 72°F or room temperature. A lighted bulb over the water is a useful adjunct on cold winter days.

The preparation of the aquarium is now complete. It should be left for about 10-15 days during which time the plants should take roots and water should remain clear. These are the signs of a balanced aquarium. If it becomes turbid or the sides turn green, the inference is that the water is not clean and that undesirable micro-organisms have gained entry. It is better to repeat the whole process to ensure a hundred per cent satisfaction later on.

Next comes the choice of fishes. This is left to the fancy of the fish-lover. A beginner may choose some hardy varieties to start with, like *Gambusia*, *Botia* or *Nemachilus*. Later he may dabble with fancy and more delicate varieties like goldfishes, *Bettas*, angel-fishes, etc.

A few hints may be added about the care and maintenance of aquarium and its fishes. The first important point to follow is the principle of feeding. 'Do not overfeed fishes' is a maxim to be strictly followed. Left-over food will naturally decay leading to putrefaction, which is unhealthy to these fragile creatures. It is better to feed them about 2-3 times daily.

Many people have an idea that water in the aquarium needs constant changing. This is a misconception. Once the aquarium is set and balanced, the water should not be changed unless it tends to become turbid or cloudy. If the level of water falls in course of time, it should be restored by the addition of some rain water or chlorine-free tap-water.

The last and most important hint is that the aquarium should be left alone, as far as possible. It should not be moved from place to place or shaken up.

APPENDIX I

NOTE ON THE NAMES OF FISHES

THE NAMES of the common Indian fishes followed in this book are those set out in the section on fishes in the series *Wealth of India*. As far as possible the corresponding names from Day's *Fishes of India* along with local names have been indicated. According to the rules of nomenclature, the name of a fish (both genus and species) is followed by the name of the author who first recorded, described or named it.

Some of the abbreviations are as follows:

Abbreviation	*Full*
Linn	— Linnaeus
Cuv and Val	— Cuvier and Valencienne
Bl & Sch.	— Bloch and Schneider
Blkr	— Bleeker
Val	— Valencienne
Cuv	— Cuvier
Lacep	— Lacepede
Forsk	— Forskal
M & H	— Muller and Henle
V. Hass	— Van Hassett

APPENDIX II

NAMES OF FISHES

	Used in the First Edition & continued in 2nd Edition	*Names according to new classification*
P 76	Carcharias tricuspidatus	Eugemphodus tricuspidatus
P 77	Carcharhinus gangeticus	Glyphis gangeticus
P 78	Sphyrana blochii	Eusphyrna blochii
P 80	Platei stequstoma *Varium*	Stegostoma fasciatum
P 93	Genus thrissocles	Genus Thrissina; Genus Thryssa
P 95	Genus Anchiovella	Genus Stolephorus
	Plate 12. Formioniger	Parastromateus niger
	Plate 15. Stromateus argenteus	Pampus argenteus
P 97	*Family* Epinepheleda	*Family* Serranidae
Do	Epinephelis	Cephalopsis
Do	Sillago domina *Day*	Sillaginopsis ponijus
P 98	Caranx (Selar) crumenophthedamus	Selar crumnenopthalamus
Do	Caranx chrysophrys	Carangoides chrysophrys
Do	Caranx djedabr	Alepes djedaba
Do	Caranx leptolepis	Selasordes leptolepis
Do	Caranx kurra	Decepturus russelti
Do	Caranx rottleri	Megalaspis cordyla
Do	Scomberoides lysan	Chorinemus
P 100	Sciaena dussumieri	Blythia dussumieri
P 103	Stromateus sinensis	Pampus Chinensis
P 105	Cynoqlossus semifasciatus	Cynoglossus macrostomus
P 106	Pisodonophis hijala	Pisodonophis boro

REFERENCES

BOOKS

Alcock, A., *A Naturalist in the Indian Seas*, John Murray, London, 1902.

Baini Prasad (Ed.), *The Wealth of India*, Vol IV, *Fish and Fisheries*, Council of Scientific and Industrial Research, New Delhi, 1962.

Berg, L. S., *Classification of Fishes, Both Recent and Fossil*, Edwards Bros., Michigan, U.S.A., 1947.

Brown, M. E. (Ed.), *Physiology of Fishes*, Vol. 1 & 2. Acad. Press, London & New York, 1957.

Budker, P., *The Life of Sharks*, Weidenfeld & Nicholson, London, 1971.

Coastean Jacques and Coqsteau, P., *The Sharks, the Cplended Savage of the Sea*, Tr. by P. Whikhead, Cassel, London, 1974.

Harmer, Herdmann, Bridge and Boulenger, Fishes and Ascidians, *Cambridge Natural History*, Vol 7, Macmillan, London, 1932.

Lanham, Url, *The Fishes*, Columbia University Press, New York, 1962.

Misra, K. S., "An Aid to the Classification of Fishes-I Elasmobranchii and Holocephali", *Records of Indian museum*, Vol. XLIX, Calcutta, 1951.

Norman, J. R., *A History of Fishes*, Earnest Ben, London, 1947.

Richard Perry, *The Unknown Ocean*, David & Charles Ltd. U.K., 1972.

Romer, A. S., *Vertebrate Palaentology*, Universsity of Chicago Press, U.S.A., 1950.

Schultz, L. and E. M.Stern, *The Ways of Fishes*, Van Nostrand, New York, 1948.

Walter, H. E., *Biology of the Vertebrates*, Macmillan, New York, 1939.

Webster, David K., *Myths and Man Eaters, The Story of Shark*, Peter Davies, London, 1962.

PERIODICALS

Central Marine Fisheries Research Institute, *Bulletin 32 & 33*, Cochin, India, 1982.

Central Marine Fisheries Research Institute, Marine Information Service, *Technical & Extension Series*, Cochin, India, 1980-84.

The Marine Products Exports Development Autority, *Marine Product Export Review* 1982, Cochin, India, 1983.

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